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LABORATORY

TECHNICAL REPORT

NO. 12909

MILITARY ADAPTATION OF COMMERCIAL ITEMS (MACI)

LABORATORY EVALUATION OF THE CODE E-436 ENGINE

February 1984

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 12909	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* Military Adaptation of Commercial Items: Laboratory Evaluation of the Code E-436 Engine		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Roy J. G. Rimpela		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Tank-Automotive Command R&D Center, DRSTA-RGRD Warren, MI 48090		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE Feb 84 13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT *(of this Report)* Approved for Public Release: Distribution Unlimited		
17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)* Diesel Engine Engine Testing NATO Standardization Engine Test		

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The project determined the military adaptability of the Code E-436 engine through laboratory testing and evaluation. The engine was installed in a dynamometer test cell at US Army Tank-Automotive Command (TACOM) and conventional dynamometer testing procedures were used to determine basic engine characteristics. The characteristics determined were full load performance, fuel economy at full load and part load, engine oil consumption, and engine heat rejection.

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During pre-endurance testing, the Code E-436 engine produced 378 observed kW (506.4 BHP) at full load, at rated speed of 2600 RPM. The maximum torque during full load operation was 1439 Nm (1061 lb-ft) at 2400 RPM. Minimum brake specific fuel consumption at full load occurred at 2200 RPM and was 217 g/KWH (0.356 lb/BHP-HR).

After the NATO Endurance Test the engine produced 375.1 observed kW (503.0 BHP) at full load and rated speed. The maximum torque was 1423.8 Nm (1050 lb-ft) at 2400 RPM.

The total lube oil consumption during the 400-hour NATO endurance was 19.7 kgs (43.4 lbs).

Following the endurance test visual and dimensional inspection of the engine revealed all major engine parts to be in excellent condition except for pistons. Five out of eight pistons developed cracks in the pin bores.

Though the engine completed the endurance test (400 hours) and was operated for a total of 582 hours, the engine is considered as having failed the 400-hour NATO test due to piston failure.

PREFACE

This test program was supervised and conducted by the US Army Tank-Automotive Command, R&D Center, Propulsion Systems Division, in test cell no. 6 of Bldg. 212. The test was started on 17 Jan 83 and was completed on 28 Jul 83.

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LIST OF ILLUSTRATIONS (PERFORMANCE GRAPHS)

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1.0. INTRODUCTION

TACOM started an engineering program in 1975 at the Propulsion Systems Laboratory for Military Adaptation of Commercial Items. The program's objectives are selection and simulated field test evaluation of current advanced technology engines to replace or update military engines in current vehicle programs.

2.0. OBJECTIVE

The test objective is to determine full- and part-load performance characteristics and engine durability through the standard 400-hour NATO Test program (AEP-5 dated June 1980) using fuel with high sulfur content (1.05 percent).

3.0. CONCLUSIONS

The engine performed satisfactorily over the full range of test speeds, both at full and part loads, and throughout the 400-hour endurance test. The engine also met manufacturer's listed performance values of power, torque, fuel economy, and heat rejection. The engine was operated for a total of 582 hours.

Although the engine performed satisfactorily and met the performance requirements, it did not meet durability requirements and therefore failed to pass the 400-hour NATO Test. Failure to pass the NATO Test was based on condition of the pistons at endurance test conclusion; five of the eight pistons had developed serious cracks in piston pin bores.

4.0. RECOMMENDATIONS

Further piston durabilty improvements would appear obtainable through the following:

- o Material improvement;
- o Change of fabrication methods;
- o Improved piston cooling;
- o Piston reinforcement or addition of another reinforcement material (insert);
- o Heat bridges added or other stress relieving methods applied.

5.0. ENGINE SPECIFICATIONS

5.1. Test Material.

5.1.1. Engine

- o Code: E-436
- o Model: VTA-903T

- o Maximum Output @ 500 ft and 85°F (152m & 29°C) - BHP (kW): 500 (373)
- o Speed @ Maximum Output - RPM: 2,600
- o Type: Compression Ign; 4 cycle; 90° Vee; 8 Cylinder
- o Aspiration: Turbocharged & Aftercooled
- o Bore-in (mm) x Stroke-in. (mm): 5.5 (140) x 4.75 (121)
- o Displacement - in^3 (litres): 903 (14.8)
- o Compression Ration: 15.5:1
- o Dry Weight (with Standard Accessories) - lb, (kg): 2,450 (1,110)
- o Piston Cooling: Drilled Rods

5.1.2. Lubricating Oil: Grade 30, MIL-L-2104-C
Referee Grade: 30
Imperial Oil Co.
(APPENDIX E)

5.1.3. Fuel: MIL-F-46162B (ME) (14 Aug 81)
0.95-1.05 percent Sulfur by Weight
(APPENDIX B)

5.2. Test Equipment. Controls equipment, and associated instrumentation of cell no. 2, Building 212 TACOM.

5.3. Test Procedure.

5.3.1. Propulsion Systems Division Test Program: Engine Operating Limits and Adjustments. (APPENDIX A)

5.3.2. NATO Test Specification: Allied Engineer Publication (AEP-5) June 1980, NATO Standard Engine Laboratory Test for Gas Turbine Engines and Diesel and Gasoline Engines. (APPENDIX D)

6.0. RESULTS AND DISCUSSION

6.1. Pre-endurance Test Performance Evaluation.

6.1.1. Full-load Performance. All data are presented as observed without corrections. The engine developed 378 observed kW (506.4 BHP) at its rated speed of 2,600 RPM. Peak torque was 1,439 N-m. (1,061 lb-ft) at 2,400 RPM. Performance details are presented in Figures 1 and 2 and Table 1.

6.1.2. Part-load Peformance. The minimum observed brake specific fuel consumption was 215 g/kW-hr (0.354 lb/HP-hr) at 1,900 RPM, at 85 percent load.

6.2. Performance and Endurance Evaluation During NATO Test.

6.2.1. Full-load Performance After 100 Hours. The engine developed 377.2 kW (505.9 BHP) at 2,600 RPM. The maximum torque occurred at 2,400 RPM and was 1,443

N-m. (1,064 lb-ft). Performance details are presented in Figures 3 and 4 and Table 2.

6.2.2. Full-load Performance After 200 Hours. The engine developed 377.2 kW (505.9 BHP) at 2,600 RPM. The maximum torque occurred at 2,400 RPM and was 1,441.4 N-m. (1063 lb-ft). Peformance details are presented in Figures 5 and 6 and Table 3.

6.2.3. Full-load Performance After 300 Hours. The engine developed 376.6 kW (505 BHP) at 2,600 RPM. The maximum torque occurred at 2,400 RPM and was 1,430.6 N-m. (1055 lb-ft). Performance details are presented in Figures 7 and 8 and Table 4.

6.2.4. Full-load Performance After 400 Hours. The engine developed 375.1 kW (503 BHP) at 2,600 RPM. The maximum torque value was 1,423.8 N-m. (1050 lb-ft) at 2,400 RPM. Performance details are presented in Figures 9 and 10 and Table 5.

6.2.5. Endurance Test (400 Hours). Although the engine completed the endurance test (400 hours) and was operated for a total of 582 hours, the engine failed the NATO Test.

6.2.6. Visual and Dimensional Inspection of Major Engine Components Following Endurance. At completion of the test, the engine was completely disassembled, and cleaned and all critical parts were visually examined, dimensionally checked, and photographed. Visual inspection and measurements revealed that virtually all components were in excellent condition. The engine components and their condition are described as follows (see APPENDIX F for photographs and APPENDIX G for Dimensional Inspection Sheets):

- Pistons - Pistons and rings showed no evidence of scoring. Rings had no breakage and were free to move in the ring grooves. Ring grooves were still tight. Piston skirts were clean - no signs of varnishing. Varnish was only evident on the bottom side of the piston heads where cooling oil made contact.

Although the outward appearance of the pistons was good, six pistons showed signs of severe stress. Cracks had developed in the piston pin bosses in the upper half of the wrist pin bores. Piston numbers 1 and 8 did not show signs of cracking. Carbon buildup on pistons and top lands was light.

- Piston Pin - No visual wear.
- Cylinders - Good appearance with only minimal wear indicated.
- Crankshaft Main Journals - Very good condition.
- Crankshaft Rod Journals - Very good condition.
- Main and Rod Bearings - No scratching and no overlay breakthrough.
- Cylinder Head Intake and Exhaust Valve Seats - Very good condition.
- Intake and Exhaust Valve Faces - Good condition.
- Camshaft - Lobes and bearing surfaces were in excellent condition.

o Gears - Crankshaft, Camshaft, Oil Pump Drive and Injection Pump Drive-good condition with no scratching or scoring.

o Oil Pump Pickup Tube - Broken at the bottom end near the pan - did not prevent oil pickup.

o Engine Torsional Vibration Damper - Showed signs of fatique failure - some of the elastomer worked loose.

6.2.7. Engine Oil Consumption. Oil consumption during the test was recorded by using the method of adding oil to the engine as required before engine start-up. Oil consumption was light. Results are shown in Table 6.

6.2.8. Oil Spectrographic Analysis. Oil samples were taken at 25-hour intervals and forwarded to the Petroleum Field Office East, New Cumberland, Pennsylvania. Report findings met NATO requirements as shown in APPENDIX E. (Oil sampling analysis was started at 126.5 hours).

6.2.9. Full-load Heat Rejection. Maximum full-load Brake Specific Heat Rejection measured 0.585 W/W (24.8 BTU/BHP-MIN) at rated speed, 2,600 RPM. The total heat rejected was 217.3 kW (12,356 BTU/MIN). Full-load heat rejection characteristics are shown in Figures 11 and 12.

6.2.10. Neither Smoke Readings nor Full-load Air Flow Were Measured. However, some data from a previously tested engine of the same model have been added to this report for general informational purposes. These data are shown in Figure 13 and Table 7.

6.2.11. Fuel Map - Data are shown in Figure 14.

6.2.12. Performance Data Sheets Required by NATO Specifications. Data are shown in APPENDIX H.

SUPPLEMENTARY NOTE: THE ILLUSTRATION AND TABLES IN PAGES 16 THROUGH 33 ARE ARRANGED IN THE FOLLOWING FORMAT:

ILLUSTRATION (METRIC UNITS)

ILLUSTRATION (ENGLISH UNITS)

TABLE (ENGLISH AND METRIC UNTIS)

ILLUSTRATIONS HAVE DUPLICATE TITLES BUT DO NOT PRESENT DUPLICATE VALUES.

FIGURE 1
ENGINE FULL LOAD PERFORMANCE (0-HOURS)

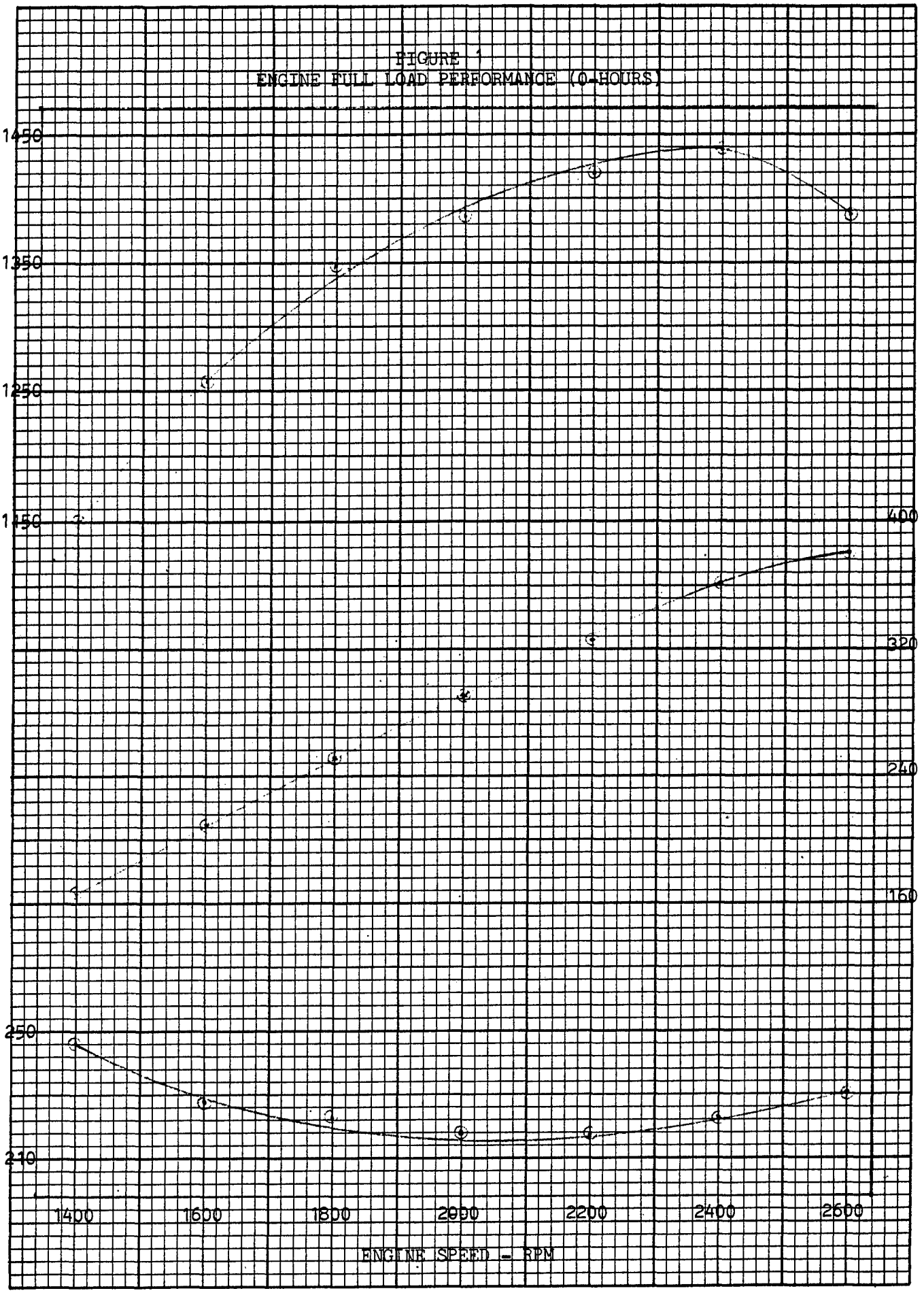
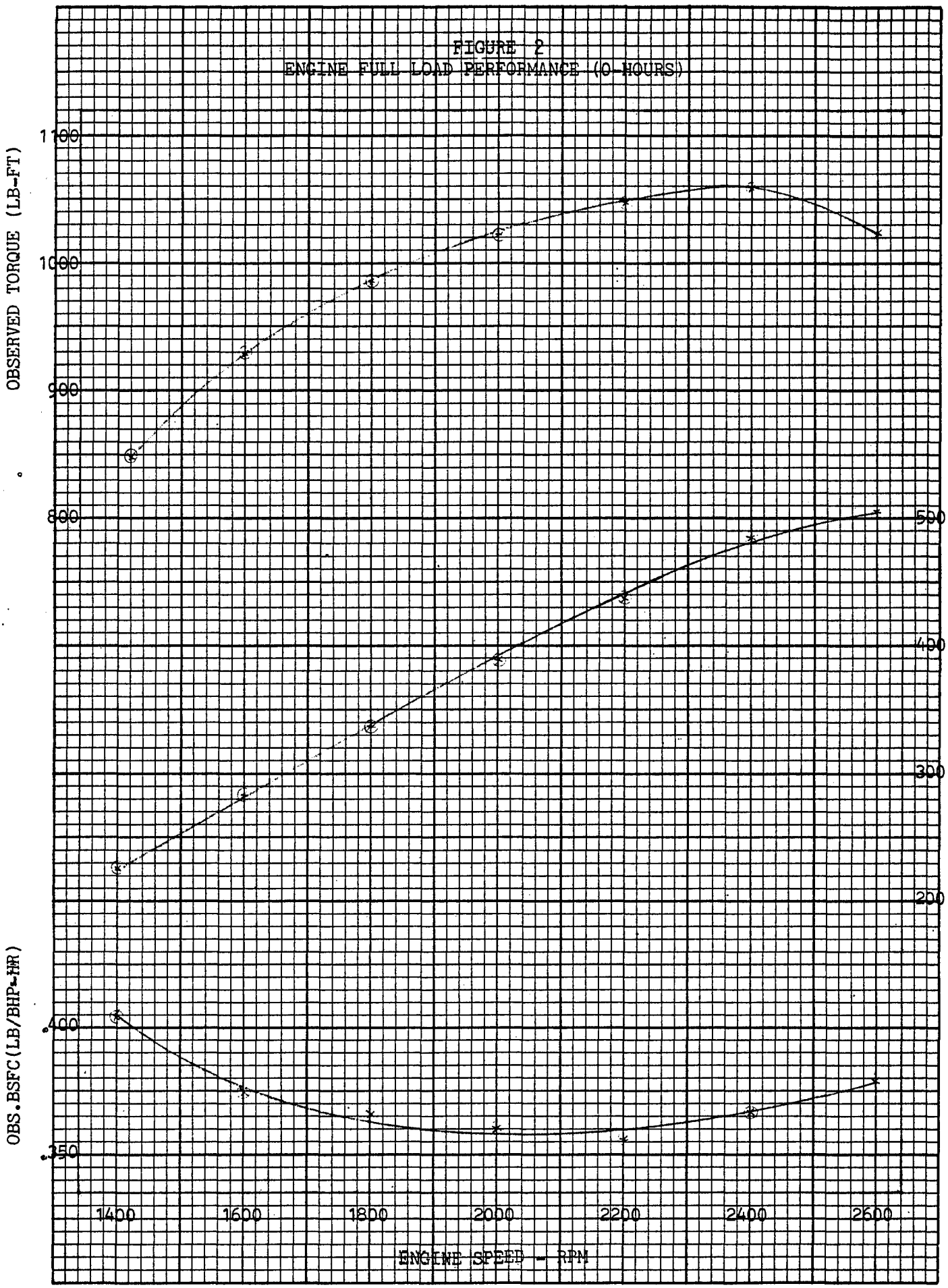


FIGURE 2
ENGINE FULL LOAD PERFORMANCE (0-HOURS)



Code E-436 Engine Full Load Performance Data
Before Endurance ± 0 Hours

SPEED (RPM)	OBSERVED TORQUE LB-FT (Nm)	OBSERVED POWER BHP (kW)	OBSERVED FUEL FLOW LB/HR (KG/HR)	OBSERVED SPECIFIC FUEL CONSUMPTION LB/BHP-HR (g/kWh)	OIL SUMP TEMP °F (°C)	AIR CLEANER OUTLET TEMP °F (°C)	FUEL TEMP TO ENGINE °F (°C)	ENGINE COOLANT OUTLET TEMP °F (°C)
2,600	1023	506.4	191.84	0.379	261	84	87	201.6
	(1387)	(378.0)	(87.02)	(231)	(127.2)	(28.9)	(30.6)	(94.2)
2,400	1061	484.8	171.76	0.367	259	86	86	202.1
	(1439	(362.0)	(77.91)	(223)	(126.1)	(30.0)	(30.0)	(94.5)
2,200	1047	438.5	156.22	0.356	257	86	88	201.7
	(1420)	(327.0)	(70.86)	(217)	(125.0)	(30.0)	(31.1)	(94.3)
2,000	1022	389.1	139.72	0.359	254	86	86	201.8
	(1386)	(290.0)	(63.38)	(218)	(123.3)	(30.0)	(30.0)	(94.3)
1,800	984	337.4	123.55	0.366	252	86	86	201.9
	(1334)	(252.0)	(56.04)	(223)	(122.2)	(30.0)	(30.0)	(94.4)
1,600	928	283.4	106.43	0.376	249	85	85	202.2
	(1258)	(211.0)	(48.28)	(228)	(120.6)	(29.4)	(29.4)	(94.6)
1,400	849	226.6	91.48	0.404	247	85	85	202.1
	(1151)	(169.0)	(41.50)	(246)	(119.4)	(29.4)	(29.4)	(94.5)

Applicable Test Conditions/Range Variations

Intake Air Restriction -4.6 to -5.8 in. H_2O (96.9 to 97.9 kPa)

Exhaust Gas Outlet Pressure +15.3 to .57 in. H_2O (101.9 to 98.2 kPa)

Dry Air Barometer: 28.77 -in. Hg (97.4 kPa)

TABLE 1

FIGURE 3

ENGINE FULL LOAD PERFORMANCE (100 HOURS)

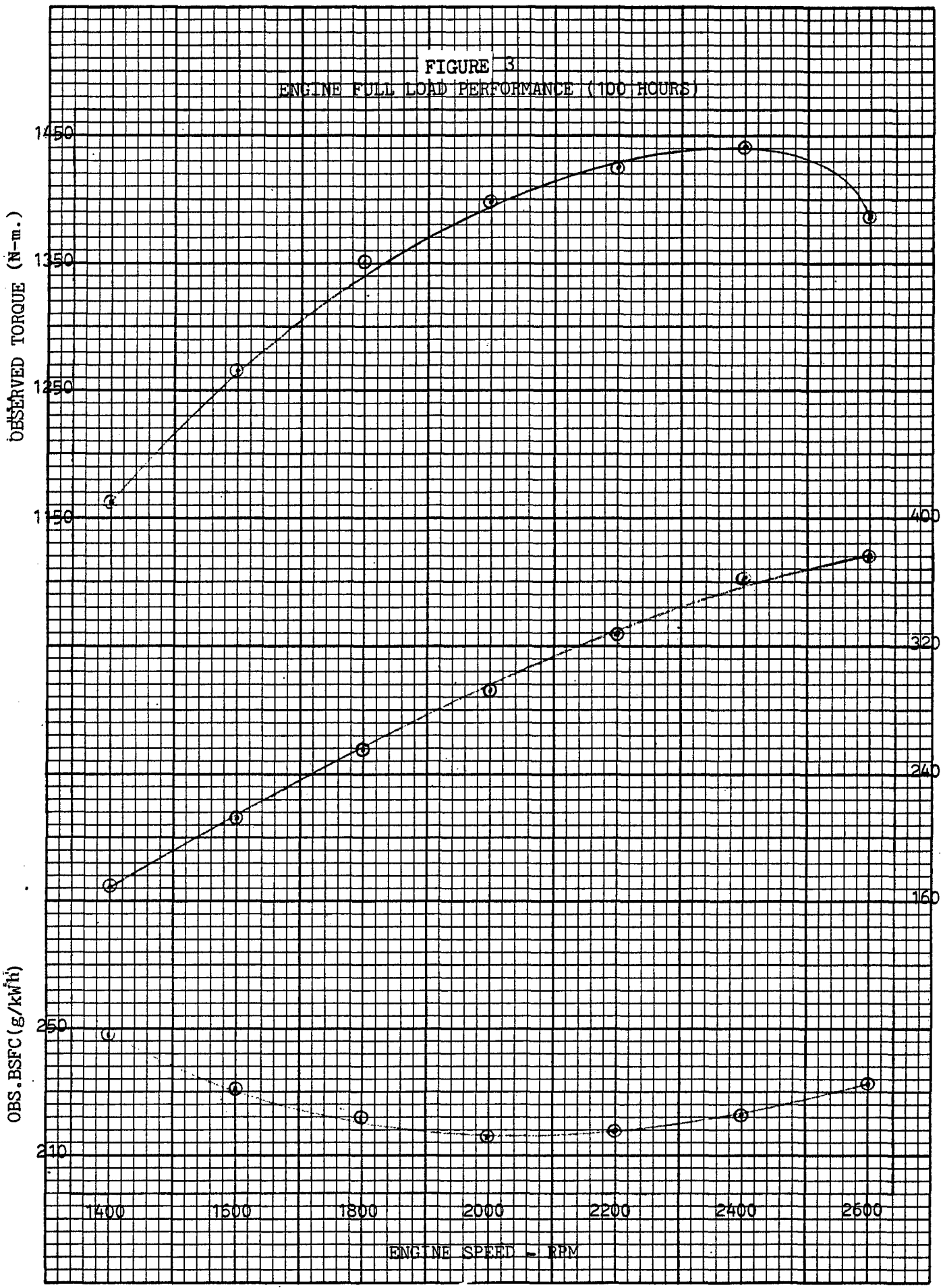
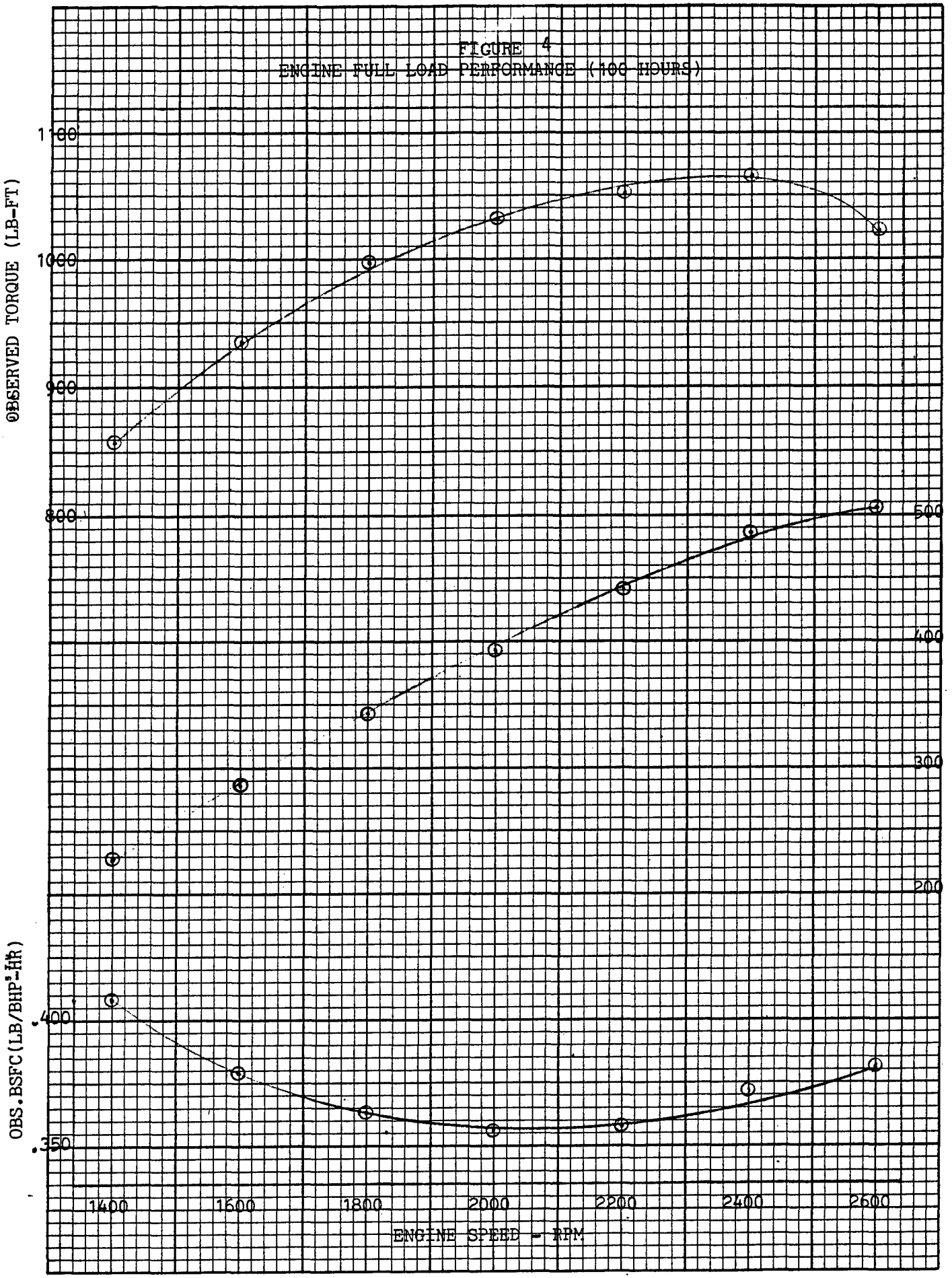


FIGURE 4

ENGINE FULL LOAD PERFORMANCE (100 HOURS)



Code E-436 Engine Full Load Performance Data

After 100 Hours of Endurance

SPEED (RPM)	OBSERVED TORQUE LB-FT (Nm)	OBSERVED POWER BHP (kW)	OBSERVED FUEL FLOW LB/HR (KG/HR)	OBSERVED SPECIFIC FUEL CONSUMPTION LB/BHP-HR (g/kWh)	OIL SUMP TEMP °F (°C)	AIR CLEANER OUTLET TEMP °F (°C)	FUEL TEMP TO ENGINE °F (°C)	ENGINE COOLANT OUTLET TEMP °F (°C)
2,600	1022 (1386)	505.9 (377.2)	193.78 (87.90)	0.383 (232.9)	260 (126.7)	78.7 (25.9)	80.4 (26.9)	202.2 (94.6)
2,400	1064 (1443)	486.2 (362.6)	178.52 (80.98)	0.367 (223.2)	256.8 (124.9)	74.2 (23.4)	82.5 (28.1)	200.7 (93.7)
2,200	1051 (1425)	440.3 (328.3)	157.45 (71.42)	0.358 (217.8)	253.9 (123.3)	75.0 (23.9)	84.5 (29.2)	200.5 (93.6)
2,000	1031 (1398)	392.6 (292.8)	139.58 (63.31)	0.356 (216.6)	252.2 (122.3)	76.8 (24.9)	82.4 (28.0)	201.8 (94.3)
1,800	997 (1352)	341.7 (254.8)	124.54 (56.49)	0.364 (221.4)	250.1 (121.2)	76.8 (24.9)	82.5 (28.1)	201.7 (94.3)
1,600	934 (1267)	284.5 (211.9)	107.87 (48.93)	0.379 (230.5)	247.6 (119.8)	79.1 (26.2)	86.9 (30.5)	201.5 (94.2)
1,400	857 (1162)	228 (170.3)	93.06 (42.21)	0.407 (247.6)	245 (118.3)	79.5 (26.4)	84.1 (28.9)	201.9 (94.4)

Applicable Test Condition/Range Variation

Intake Air Restriction -5.3 to -1.2 in. H_2O (96.7 to 97.8 kPa)

Exhaust Gas Outlet Pressure 14.3 to .8 in. H_2O (101.6 to 98.3 kPa)

Dry Air Barometer: 29.08 in. Hg (196.5 kPa)

TABLE 2

FIGURE 6
ENGINE FULL LOAD PERFORMANCE (200-HOURS)

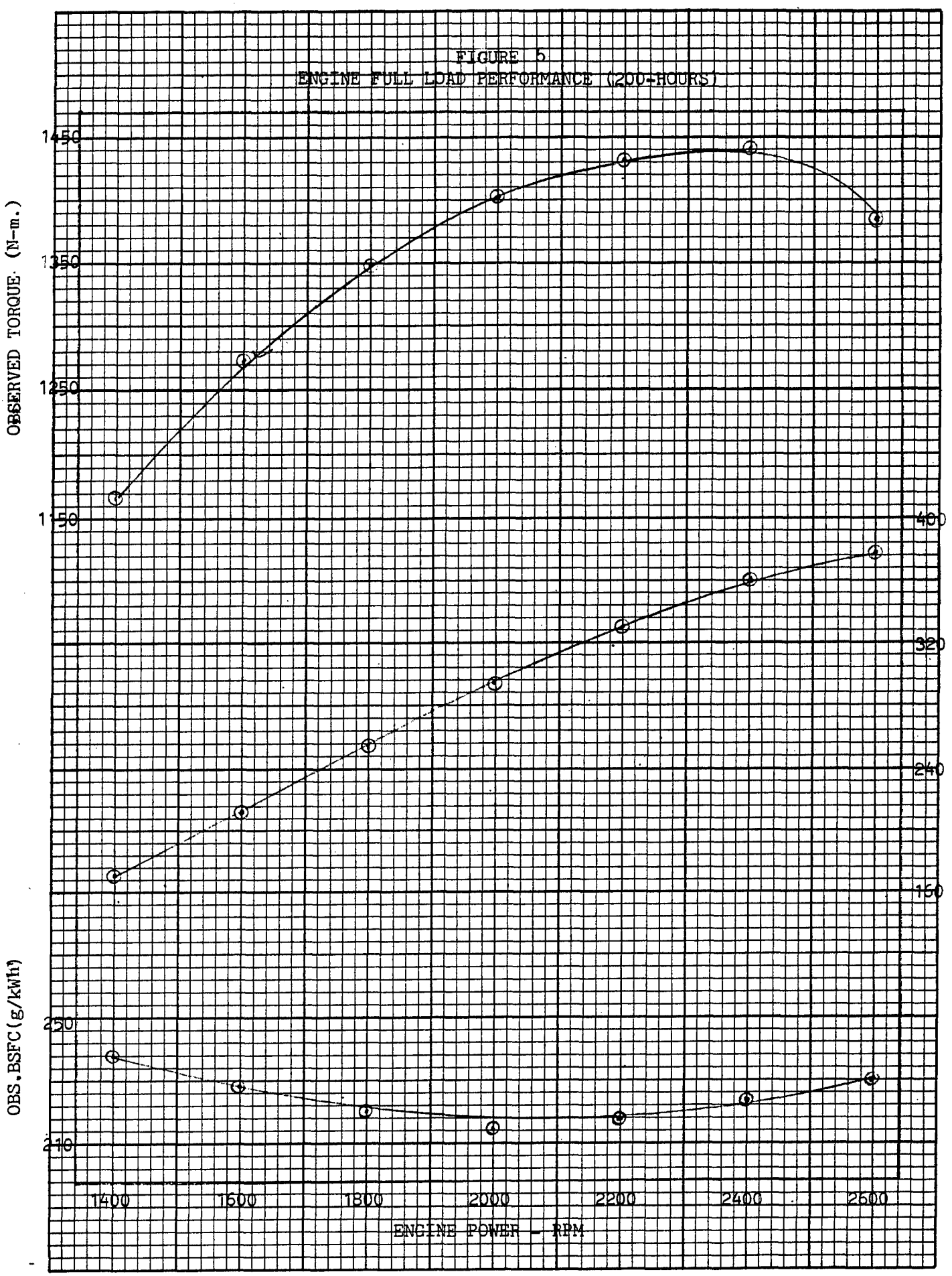
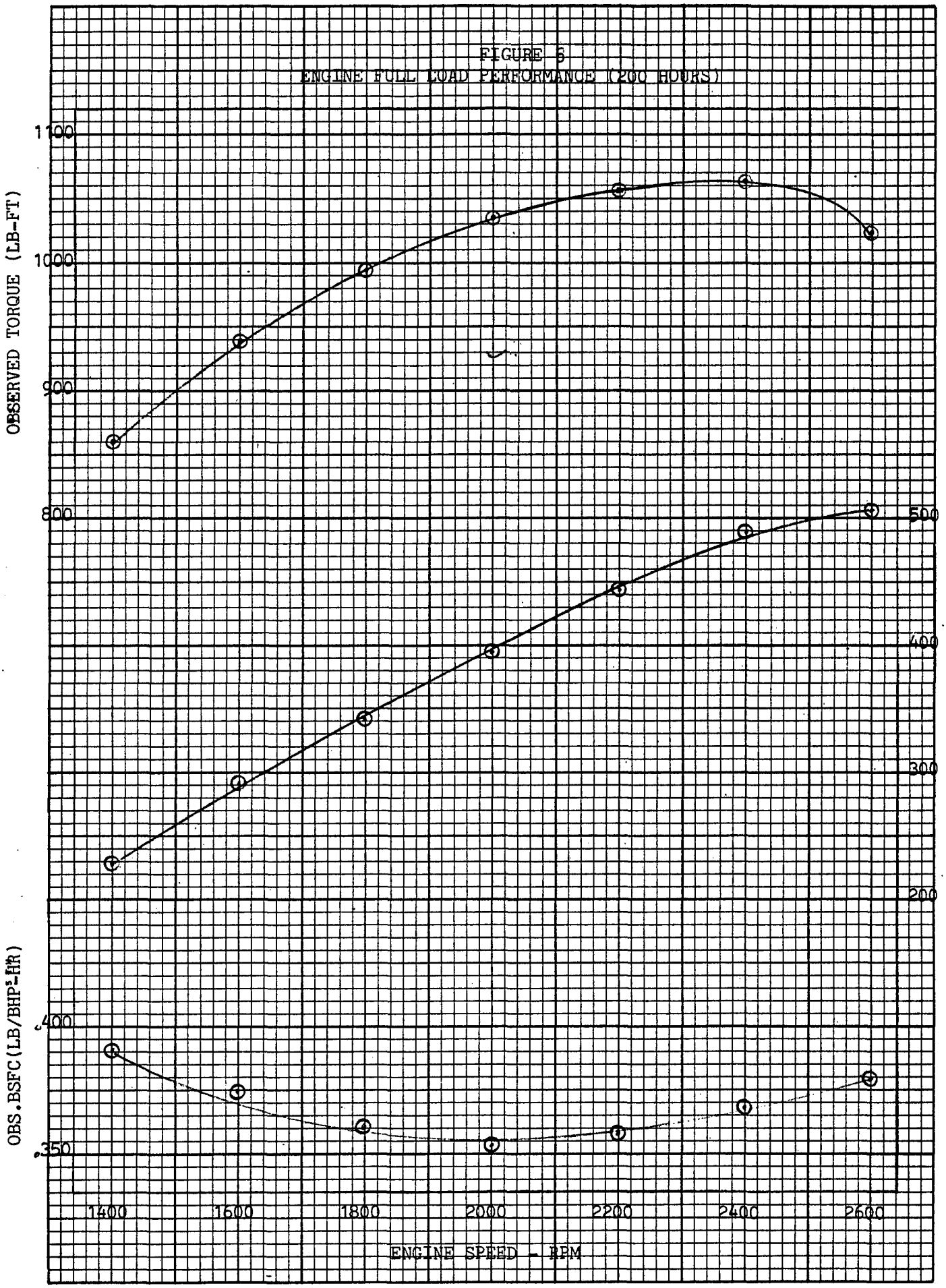


FIGURE 6
ENGINE FULL LOAD PERFORMANCE (200 HOURS)



Code E-436 Engine Full Load Performance Data

After 200 Hours of Endurance

SPEED (RPM)	OBSERVED TORQUE LB-FT (Nm)	OBSERVED POWER BHP (kW)	OBSERVED FUEL FLOW LB/HR (KG/HR)	OBSERVED SPECIFIC FUEL CONSUMPTION LB/BHP-HR (g/kWh)	OIL SUMP TEMP °F (°C)	AIR CLEANER OUTLET TEMP °F (°C)	FUEL TEMP TO ENGINE °F (°C)	ENGINE COOLANT OUTLET TEMP °F (°C)
2,600	1022 (1385.8)	505.9 (377.2)	191.88 (87.04)	0.379 (230.5)	257.9 (125.5)	69.6 (20.9)	83.6 (29.7)	200.7 (93.7)
2,400	1063 (1441.4)	483.5 (360.5)	177.98 (80.73)	0.368 (223.9)	257.1 (125.1)	71.5 (21.9)	83.0 (28.3)	202.0 (94.4)
2,200	1056 (1431.9)	442.3 (329.8)	158.30 (71.80)	0.358 (217.8)	254.9 (123.8)	73.8 (23.2)	81.4 (27.4)	201.6 (94.2)
2,000	1034 (1402.1)	393.8 (293.7)	138.98 (63.04)	0.353 (214.7)	252.4 (122.4)	74.8 (23.8)	82.2 (27.9)	201.4 (94.1)
1,800	994 (1347.8)	340.7 (254.1)	122.99 (55.79)	0.361 (219.6)	250.0 (121.1)	74.4 (23.6)	83.6 (28.7)	201.4 (94.1)
1,600	939 (1273.3)	286.1 (213.3)	106.98 (48.53)	0.374 (227.5)	247.7 (119.8)	76.3 (24.6)	82.9 (28.3)	201.4 (94.1)
1,400	861 (1167.5)	229.5 (171.1)	89.80 (40.73)	0.391 (237.8)	245.4 (118.6)	75.7 (24.3)	83.3 (28.5)	201.5 (94.2)

Applicable Test Conditions/Range Variations

Intake Air Restriction -5.5 to -1.3 in. H^2O (96.7 to 97.7 kPa)

Exhuast Gas Outlet Pressure 19.0 to .2 in. H^2O (102.8 to 98.1 kPa)

Dry Air Barometer: 29.43 -in. Hg (99.6 kPa)

TABLE 3

FIGURE 7
ENGINE FULL LOAD PERFORMANCE (300-HOURS)

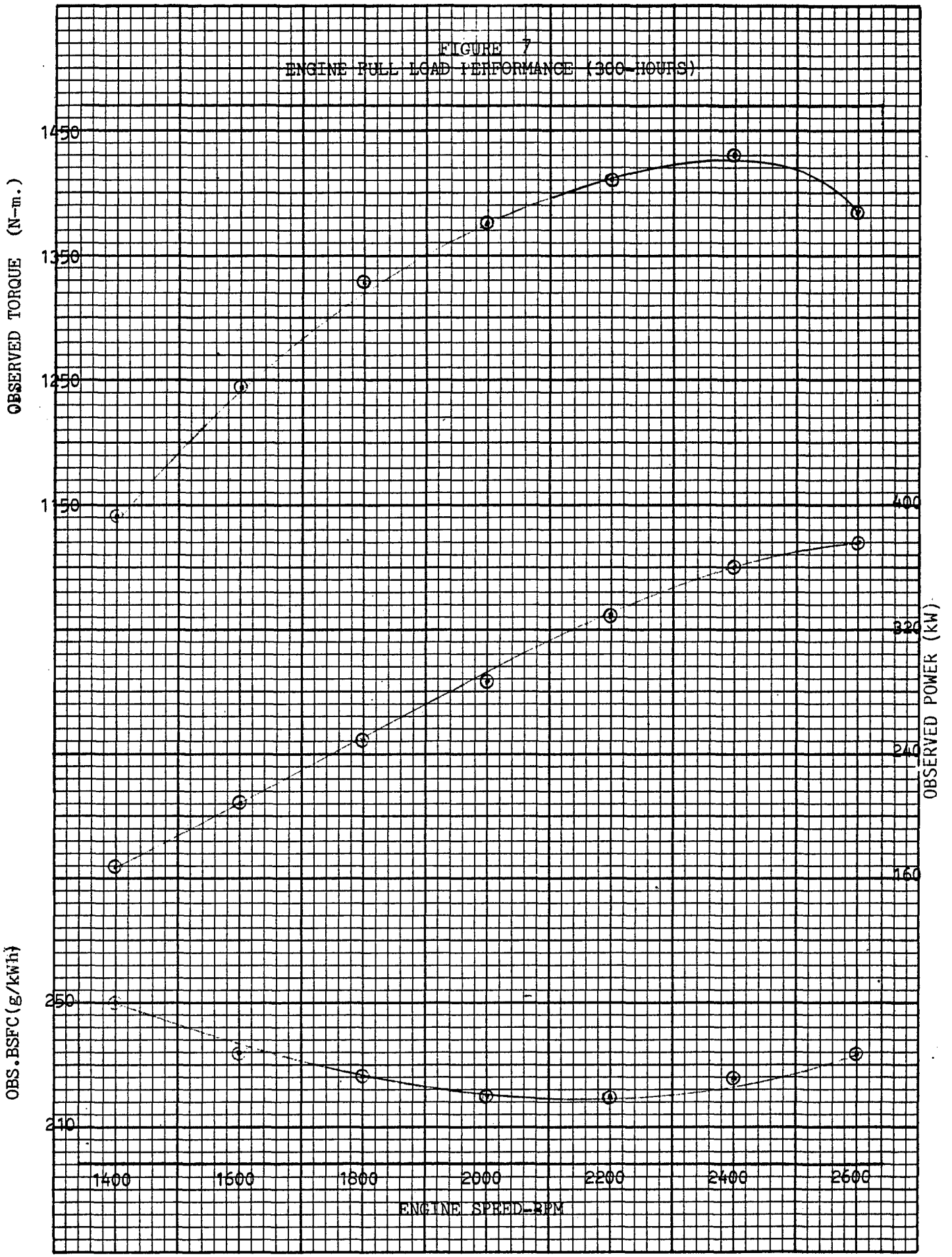
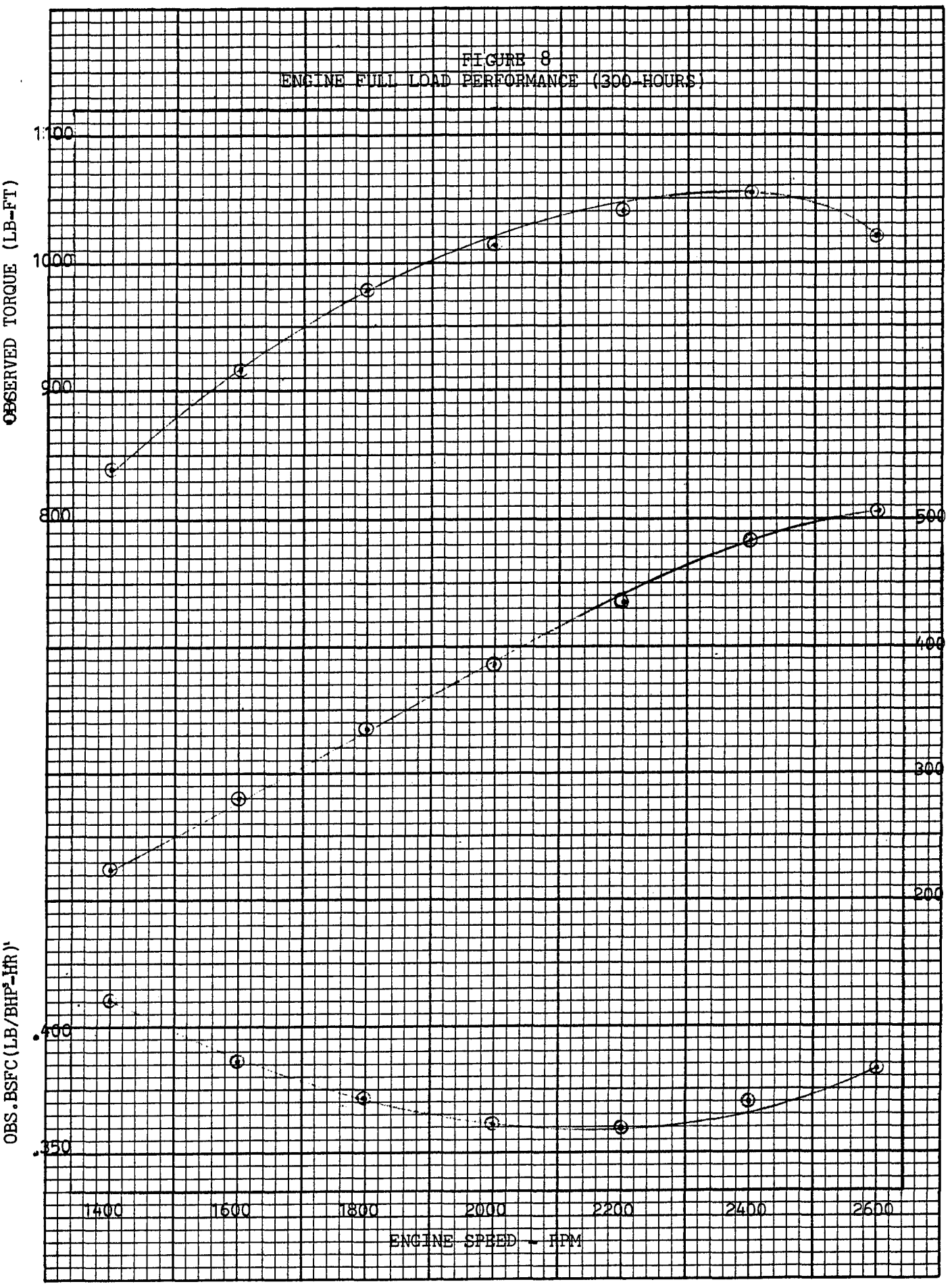


FIGURE 8
ENGINE FULL LOAD PERFORMANCE (300-HOURS)



Code E-436 Engine Full Load Performance Data

After 300 Hours of Endurance

SPEED (RPM)	OBSERVED TORQUE LB-FT (Nm)	OBSERVED POWER BHP (kW)	OBSERVED FUEL FLOW LB/HR (KG/HR)	OBSERVED SPECIFIC FUEL CONSUMPTION LB/BHP-HR (g/kWh)	OIL SUMP TEMP °F (°C)	AIR CLEANER OUTLET TEMP °F (°C)	FUEL TEMP TO ENGINE °F (°C)	ENGINE COOLANT OUTLET TEMP °F (°C)
2,600	1020 (1383.1)	505.0 (376.6)	193.45 (87.75)	0.383 (233.0)	257.2 (125.1)	80.8 (27.1)	85.5 (29.7)	199.6 (93.1)
2,400	1055 (1430.6)	482.1 (359.5)	178.77 (81.09)	0.371 (225.7)	255.1 (123.9)	79.9 (26.6)	84.9 (29.4)	198.8 (92.7)
2,200	1040 (1410.2)	435.6 (324.8)	157.01 (71.22)	0.360 (219.0)	251.2 (121.8)	78.4 (25.8)	83.3 (28.5)	198.7 (92.6)
2,000	1013 (1373.6)	385.7 (287.6)	139.74 (83.39)	0.362 (220.2)	247.9 (119.9)	71.6 (22.0)	81.5 (27.5)	198.5 (92.5)
1,800	997 (1327.5)	335.5 (250.2)	125.17 (56.78)	0.373 (226.9)	245.7 (118.7)	70.0 (21.1)	82.3 (27.9)	198.7 (92.6)
1,600	918 (1244.8)	279.7 (208.6)	108.00 (48.99)	0.386 (234.8)	243.6 (117.6)	70.0 (21.1)	81.0 (27.2)	198.7 (92.6)
1,400	840 (1139.0)	223.9 (167.0)	92.31 (41.87)	0.412 (250.6)	240.9 (116.1)	70.2 (21.2)	82.4 (28.0)	198.7 (92.6)

Applicable Test Conditions/Range Variations

Intake Air Restriction -6.1 to -1.4 in. H^2O (96.6 to 97.7 kPa)

Exhaust Gas Outlet Pressure 18.3 to .12 in. H_2O (102.6 to 98.1 kPa)

Dry Air Barometer: 28.67 -in. Hg (97.1 kPa)

TABLE 4

FIGURE 9
ENGINE FULL LOAD PERFORMANCE (400-HOURS)

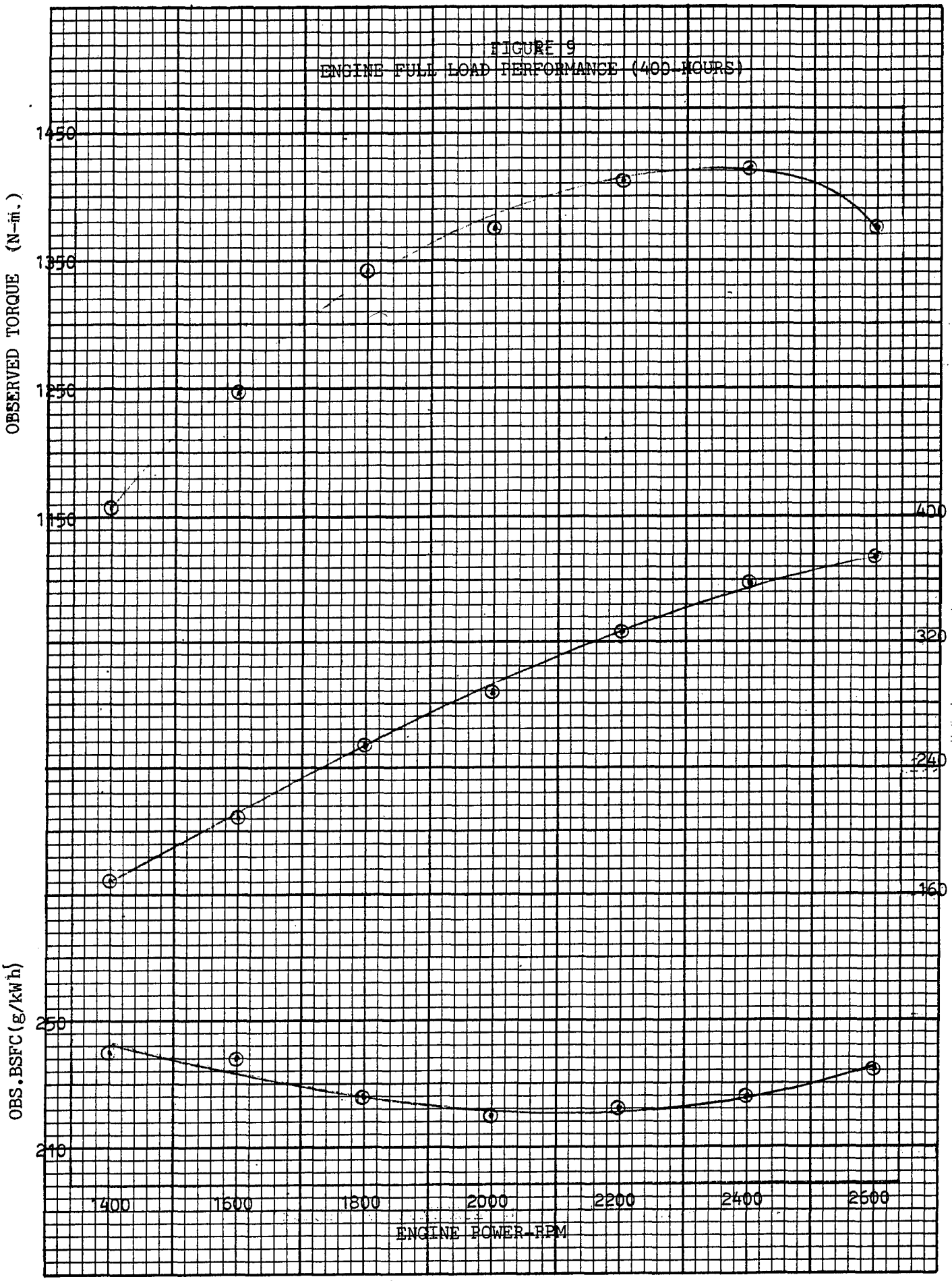
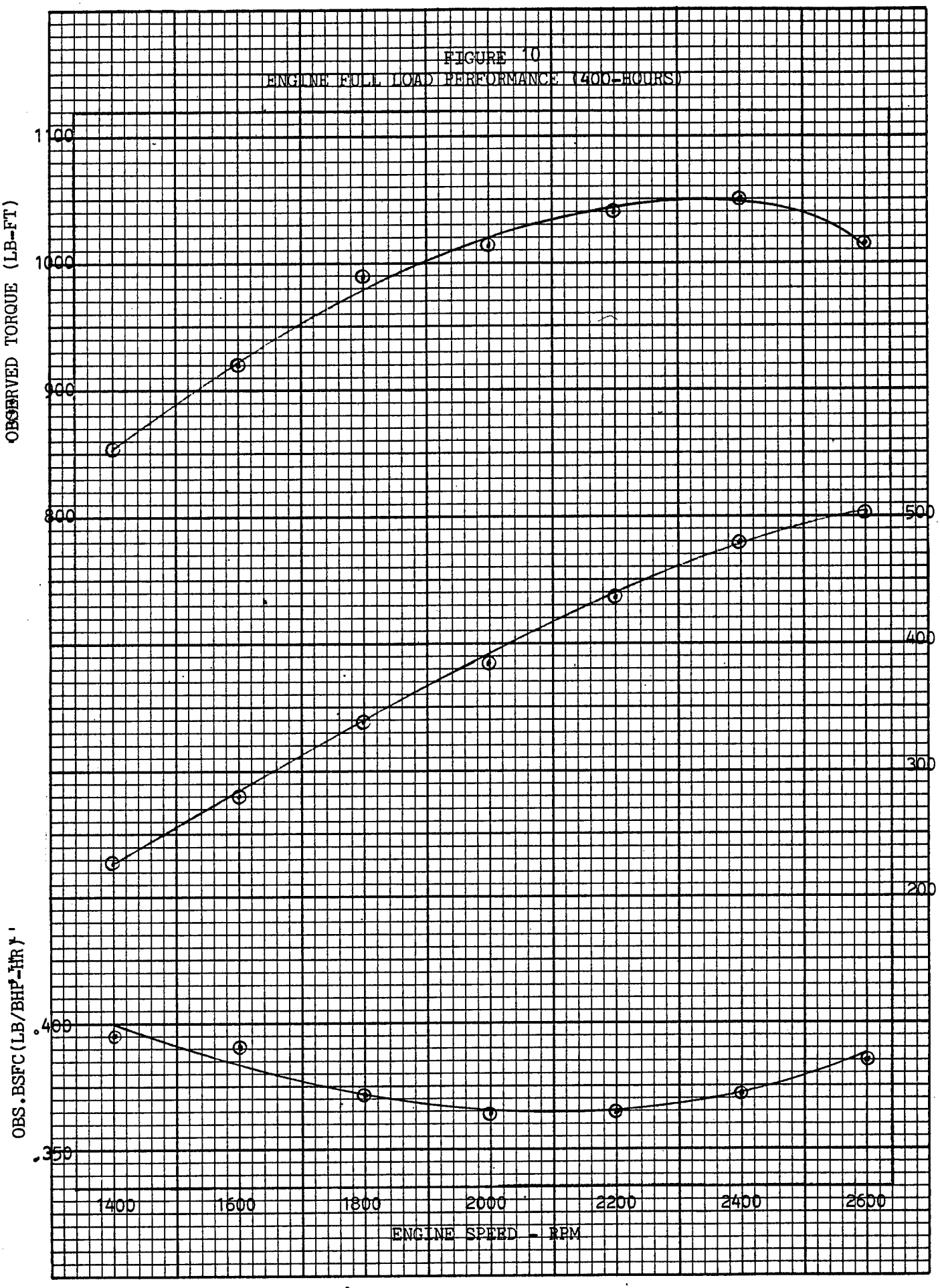


FIGURE 10

ENGINE FULL LOAD PERFORMANCE (400-HOURS)



Code E-436 Engine Full Load Performance Data

After 400 Hours of Endurance

SPEED (RPM)	OBSERVED TORQUE LB-FT (Nm)	OBSERVED POWER BHP (kW)	OBSERVED FUEL FLOW LB/HR (KG/HR)	OBSERVED SPECIFIC FUEL CONSUMPTION LB/BHP-HR (g/kWh)	OIL SUMP TEMP °F (°C)	AIR CLEANER OUTLET TEMP °F (°C)	FUEL TEMP TO ENGINE °F (°C)	ENGINE COOLANT OUTLET TEMP °F (°C)
2,600	1016 (1377.7)	503.0 (375.1)	193.71 (87.87)	0.395 (234.2)	259.1 (126.2)	79.5 (26.4)	87.3 (30.7)	201.1 (93.9)
2,400	1050 (1423.8)	479.8 (357.8)	178.66 (81.04)	0.372 (226.3)	256.6 (124.8)	78.6 (25.9)	87.9 (31.1)	201.3 (94.1)
2,200	1041 (1411.6)	436.1 (325.2)	159.18 (72.20)	0.365 (222.0)	253.3 (122.9)	77.5 (25.3)	85.7 (29.8)	201.4 (94.1)
2,000	1014 (1375.0)	386.1 (287.9)	140.43 (63.70)	0.364 (221.4)	250.2 (121.2)	77.5 (25.3)	85.6 (29.8)	201.3 (94.1)
1,800	990 (1342.4)	339.3 (253.0)	126.11 (57.20)	0.372 (226.3)	247.8 (119.9)	77.3 (25.2)	85.0 (29.4)	201.6 (94.2)
1,600	921 (1248.9)	280.6 (209.2)	109.70 (49.76)	0.391 (237.8)	244.6 (118.1)	77.2 (25.1)	84.0 (28.9)	201.5 (94.2)
1,400	853 (1156.7)	227.4 (169.6)	89.77 (40.72)	0.395 (240.3)	237.8 (114.3)	76.9 (24.9)	82.0 (27.8)	198.8 (92.7)

Applicable Test Conditions/Range Variations

Intake Air Restriction -5.8 to 1.3 in. H_2O (96.6 to 98.4 kPa)

Exhaust Gas Outlet Pressure 19 to .03 in. H_2O (102.8 to 98.1 kPa)

Dry Air Barometer: 28.96 -in. Hg (98.1 kPa)

TABLE 5

Oil Consumption During Endurance

Engine Test Hours	Quantity Oil Added (lb)	Cumulative Consumption (lb)
0	0	SUMP FULL
7.5	3.6	3.6
14.0	1.8	5.4
27.5	1.8	7.2
40.0	1.8	9.0
47.5	1.8	10.8
54.0	3.6	14.4
60.5	1.8	16.2
80.5	1.8	18.0
87.5	1.8	19.8
100.	0	19.8
140.5	1.8	21.6
154.0	2.1	23.7
160.0	1.8	25.5
174.0	2.5	28.0
187.0	1.8	29.8
200.0	0	29.8
230.0	3.6	33.4
260.0	1.4	34.8
287.0	2.0	36.8
300.0	0	36.8
307.0	1.5	38.3
314.0	1	39.3
334.0	1.9	41.2
354.0	.5	41.7
370.0	1.2	42.9
380.0	.5	43.4
400.	0	43.4

TABLE 6

FIGURE 11
FULL LOAD HEAT REJECTION

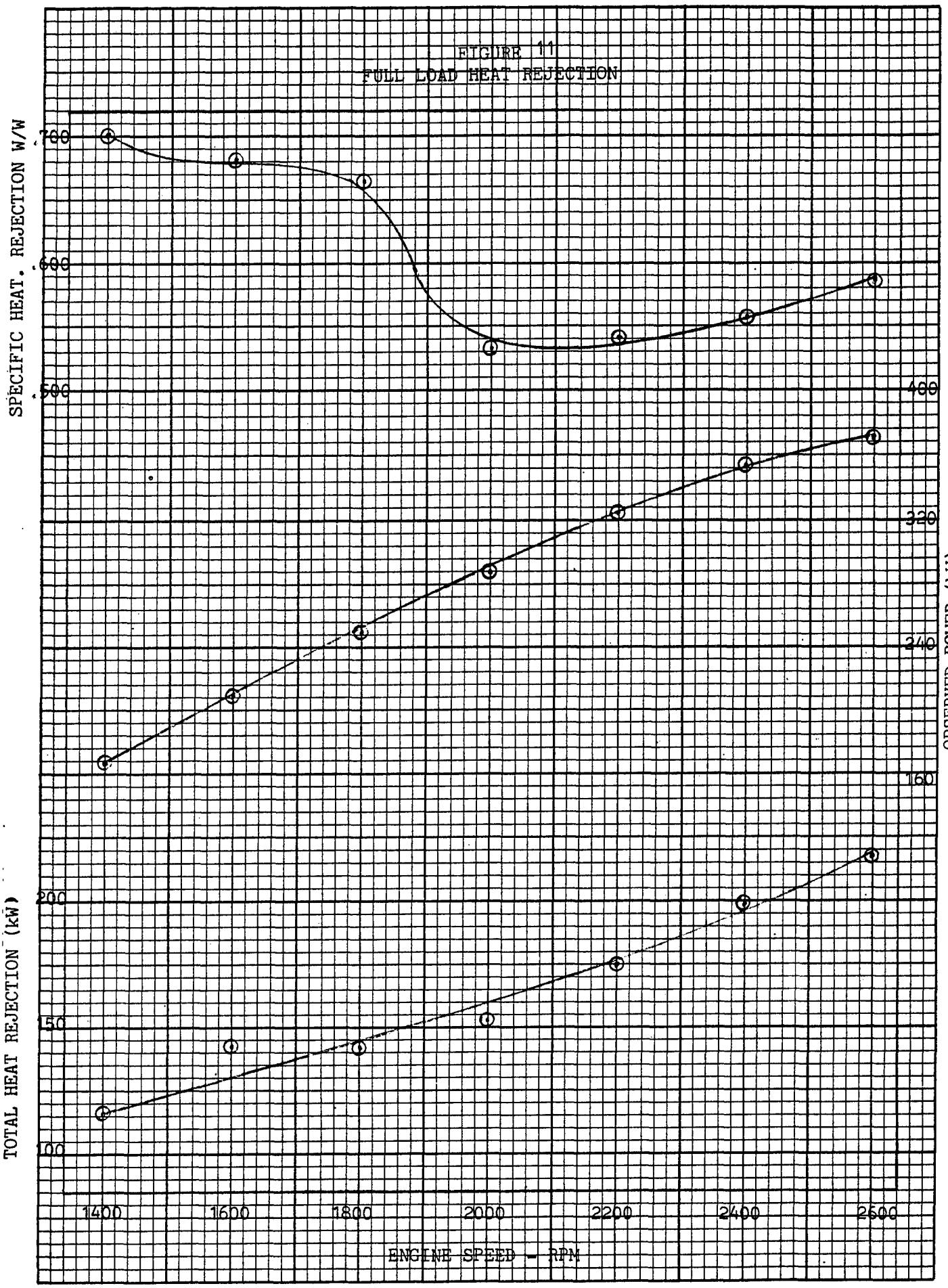
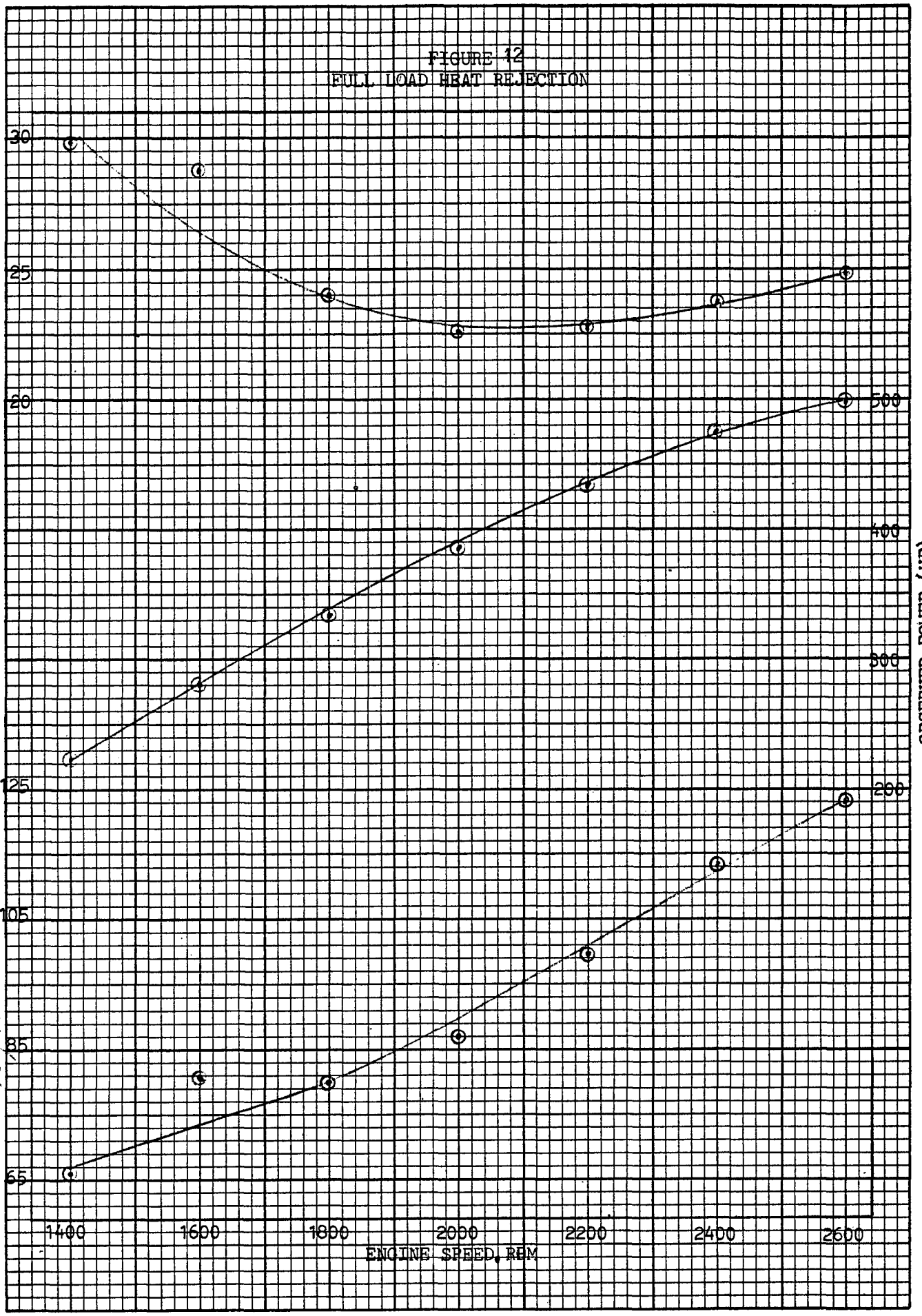


FIGURE 12
FULL LOAD HEAT REJECTION



FULL POWER INLET AIR FLOW

NOTE: (These values not from engine tested but from an engine of the same model and are submitted as general information)

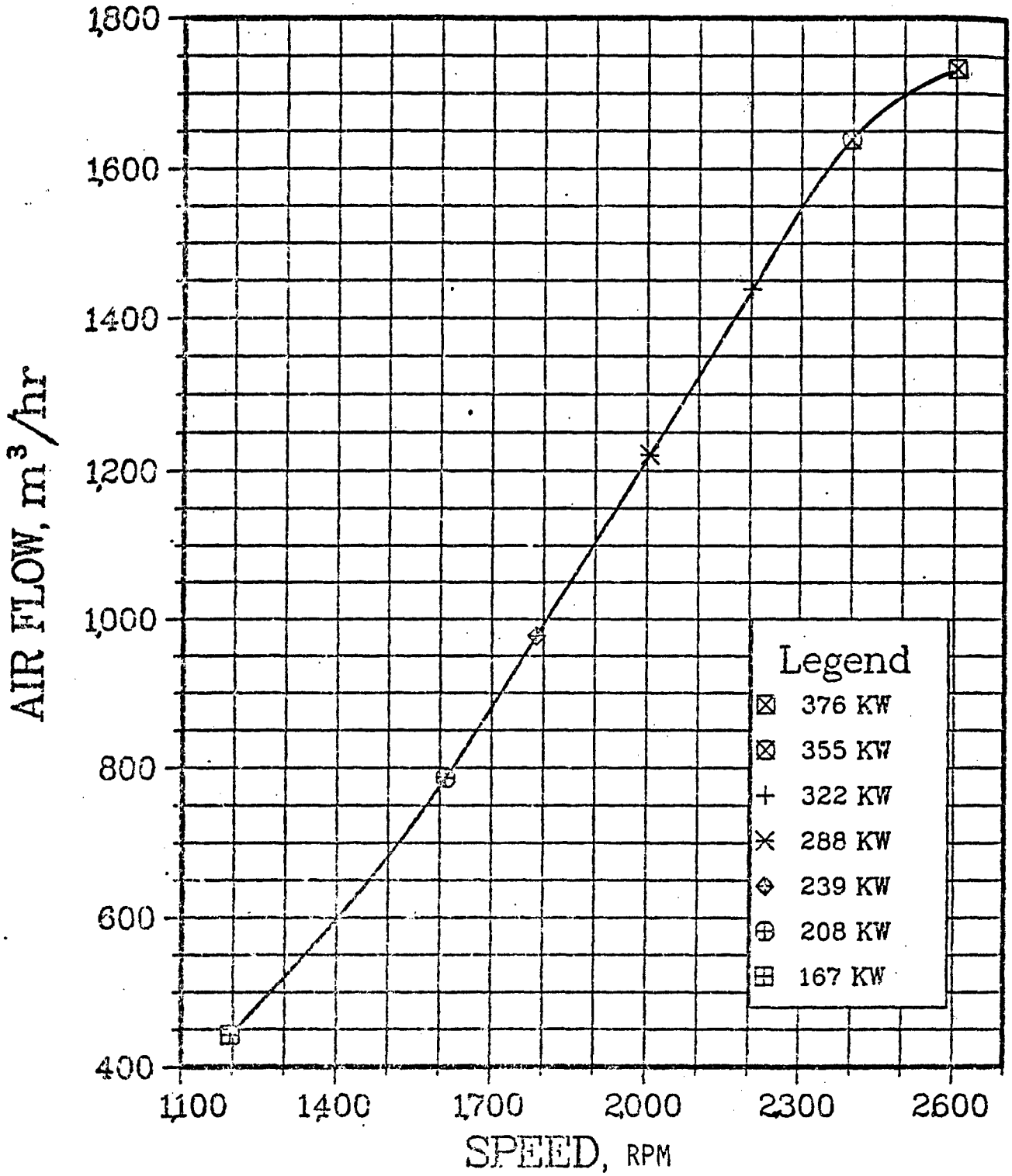


Figure 13 FULL POWER INLET AIR FLOW

AIR FLOW UNITS. STANDARD CUBIC METRES PER HOUR

NOTE: (These values not from engine tested but from an engine of the same model and are submitted as general information)

SPEED	ENDURANCE HOURS		
RPM	0 HOURS	100 HOURS	200 HOURS
2,600	1.4	1.85	1.65
2,400	1.05	1.5	1.35
2,200	1.1	1.45	1.55
2,000	1.35	2.0	1.8
1,800	3.25	3.8	3.8
1,600	3.25	3.8	3.8

TABLE 7. BOSCH SMOKE READINGS

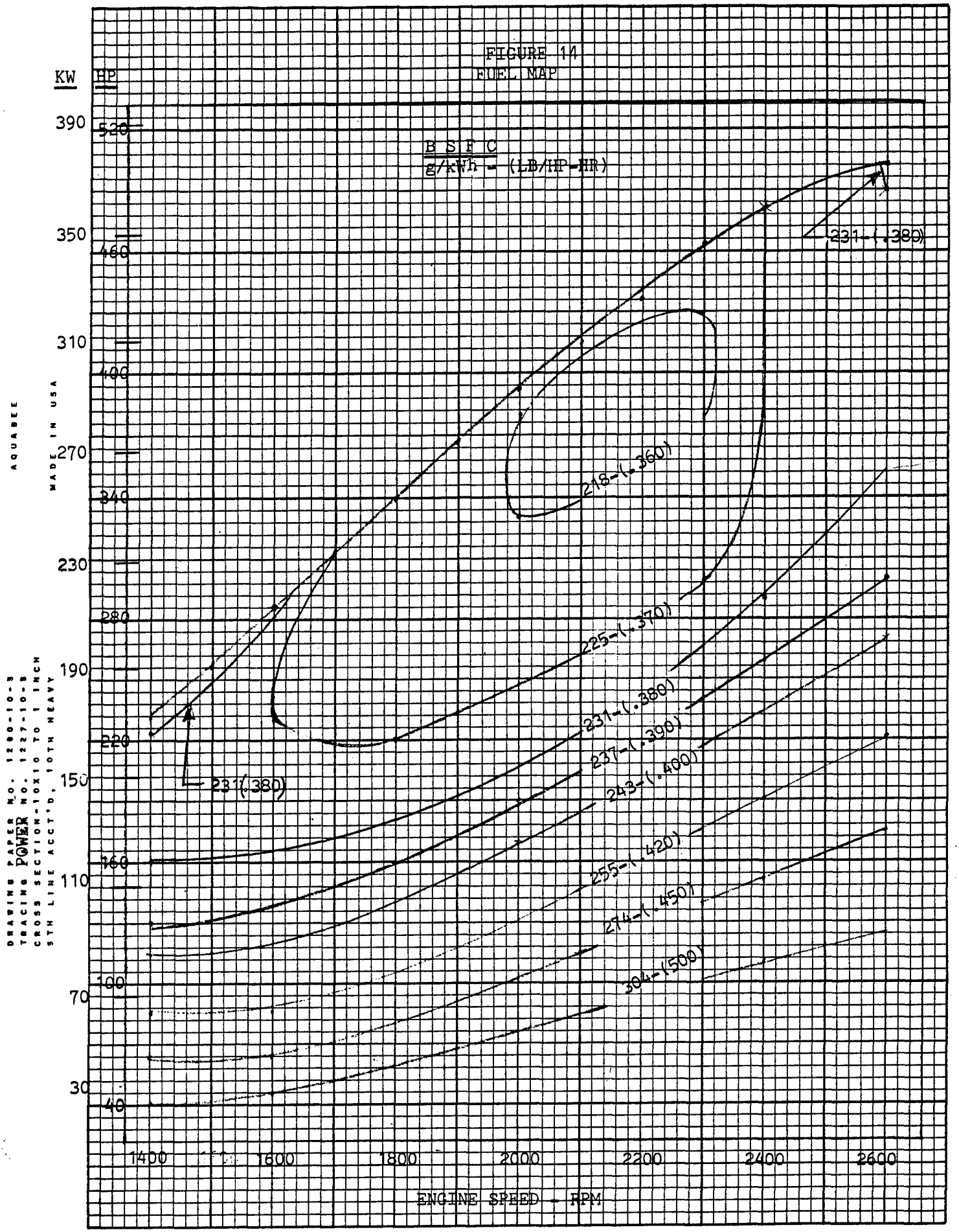


FIGURE 14
FUEL MAP
KW
HP
390
520
350
460
310
400
270
340
230
280
190
220
150
160
110
100
70
30
40
B S F C
g/kWh - (LB/HP-HR)
231-(.380)
218-(.360)
225-(.370)
231-(.380)
237-(.390)
243-(.400)
255-(.420)
274-(.450)
304-(500)
231(380)
1400
1600
1800
2000
2200
2400
2600
ENGINE SPEED - RPM
AQUABEE
MADE IN USA
DRAWING PAPER NO. 1280-10-5
TRACING POWER NO. 1227-10-5
CROSS SECTION-10X10 TO 1 INCH
5TH LINE ACCT'D, 10TH HEAVY

APPENDIX A - TEST PROGRAM

PROPULSION SYSTEMS DIVISION

TEST PROGRAM CODE E-436 ENGINE

(Cell #6)

TITLE: MACI Evaluation of the Code E-436 Engine

PURPOSE:

To determine the military adaptability and performance characteristics of Code E-436 Commercial Diesel Engine.

OUTLINE OF TESTS:

1. Prepare Code E-436 engine for performance and endurance tests.
2. Install instrumentation.
3. Calibration of instrumentation and equipment.
4. Engine operating limits, adjustments and instrumentation checkout.
5. Engine instrumentation and full load operational check-out.
6. Full load performance.
7. Part load performance.
8. Full load heat rejection.
9. Four hundred hour NATO endurance test.
10. Disassembly, visual inspection and components measurement of engine (may be conducted in-house and/or contractor's facility).
11. Evaluation of results and final report.

TEST MATERIAL:

1. Engine Code E-436

Type	90° VEE, 500 HP @ 2600 rpm
Number of cylinders	8
Bore and stroke, in.	5.50 x 4.75
Displacement - cu. in.	903
Method of operation	4 cycle turbocharged, after cooled compression ignition
Compression ratio	15.5 to 1

2. Lubricating oil - Referee, grade 30, conforming to Military Specification MIL-L-2104C.

3. Fuel - Federal Specification MIL-F-46162B (high sulfur).

TEST EQUIPMENT:

Test Cell No 6, dynamometer, controls, associated instrumentation and equipment, Bldg. 212.

TEST PROCEDURES:

1. Prepare engine for performance tests.

a. Install engine in test cell and make connections to dynamometer. Obtain dry weight of engine and record. Make necessary fuel, exhaust, and intake air connections. Install cooling tower and fuel throttle and shutdown connection. Make provisions for smoke readings and measuring air flow.

b. Install all required thermocouples, pressure lines, speed and load cell connections. Install warning/shutdown lights for critical temperature/pressure and RPM limits on engine and dynamometer equipment.

c. During heat rejection tests, normal type cooling tower will be installed. Thermostat is required to be blocked in open position during test to assure accurate results. An engine thermostat (180° F) will be used. The cooling tower will be adjusted to maintain 205° F ± 5° engine out temperature.

d. Engine blow-by and/or crankcase pressure will be closely monitored during full power performance run to assure adequate engine operation. In addition engine oil temperature and pressure will be closely monitored.

e. Cooling tower will utilize a sight class in the lower pipe (engine filled with a 50/50 water and antifreeze mixture. A 15 psi pressure cap will be used and shop air, through a regulator, will supply approximately 12 psi pressure to the cooling system.

2. Instrumentation - Install instrumentation to obtain and record data at each specified speed.

a. Temperature, °F		Range	Accuracy
(1)	Air, cell ambient (L&R)	60-120	± 2
(2)	Air entrance to air meter	60-120	± 2
(3)	Air turbo inlet after air cleaner	60-120	± 2
(4)	Air, turbo outlet (to aftercooler, R&L)	120-500	± 2
(5)	Exhaust, after turbo	200-1200	±10
(6)	Exhaust, before turbo (L&R)	200-1400	±10
(7)	Exhaust, ports (8)	200-1500	±10
(8)	Oil sump	120-300	± 2
(9)	Fuel, before transfer pump	60-120	± 2
(10)	Fuel Spill	60-160	± 2
(11)	Coolant, engine inlet **	120-250	± 2
(12)	Coolant, engine outlet **	120-250	± 2
(13)	Combustion air at meter (Meriam flow meter)	30-160	± 2
(14)	Cooling water, tower inlet *	35-100	
(15)	Cooling water, tower outlet *	35-250	
(16)	Engine oil gallery (manifold)	60-270	
(17)	Instrumentation bath	200	± 2

* Indicates Quartz Temperature Probes
** Indicates Quartz Temperature Probes in addition to regular thermocouple

b. Pressures, Gauge	Range	Accuracy
(1) Air, Test cell (in. H_2O)	0 to -1	±.1
(2) Air, before turbo (in. H_2O)-S	0 to -25	± 1
(3) Air, after turbo (in. hg)	0 to +60	±.2
(4) Air across Meriam flow meter (in. H_2O)	0 to -28	±.1
(5) Air at Meriam flow meter center (in. H_2O)	0 to -20	±.05
(6) Air crankcase (in. H_2O)	-5 to +5	±.1
(7) Exhaust, before turbo (in. hg) Left & Right	0 to +60	±.5
(8) Exhaust, outlet (in. H_2O)-S	0 to +50	--
(9) Fuel supply before transfer pump (psi) at primary filter	0 to -5	±.1
(10) Fuel supply after transfer pump (psi) at secondary filter	0 to +70	± 1
(11) Engine oil gallery (psi)	0 to +100	± 2
(12) Coolant pump outlet (psi)	0 to +50	± 2
(13) Coolant pump inlet (psi)	0 to +25	± 1
c. Miscellaneous		
(1) Engine speed, (RPM)	0 - 3000	± 5
(2) Dynamometer load, (ft-lb)	0 - 2000	± 1
(3) Fuel flow (lb/hr)	200	±.1
(4) Blowby (CFM)	0 - 10	±.2
(5) Smoke Density, Bosch meter	--	--

d. Special Instruction Considerations

(1) Dymec data acquisition system to be used for data gathering.

(2) Quartz Thermometers to be used for heat rejection test.

(3) Load cell to be used for measuring torque.

(4) Digital Cox fuel weigh system to be used for measuring fuel consumption.

(5) Cooling water weigh system 0-200 lbs.

(6) Smoke density, Bosch system.

(7) Blowby meter for measuring engine blowby.

(8) Temperature reference bath (Maintain at 200° F).

(9) Meriam air flow meter.

e. The following monitors will be provided for operator use:

Temperature	Pressure
(1) Ambient air (L&R)	(1) Oil Gallery
(2) Air after turbo	(2) Air after turbo
(3) Oil gallery	(3) Fuel after pump
(4) Fuel before pump	(4) Exhaust back pressure
(5) Engine coolant in	
(6) Engine coolant out	

3. Calibration of instrumentation and equipment.

All instrumentation and equipment will be calibrated prior to start of test and at ranges specified in the previous paragraph 2.

4. Engine operating limits and adjustments.

a./ Observe the following engine operating limits and test conditions for performance and endurance tests.

(1) Oil Gallery temperature, 250° F warning, 260° F manual return to idle and contact test engineer.

(2) Oil pressure idle 15 PSI warning, 10 PSI shutdown. Oil pressure normal operation 45 to 65 PSI above 1000 RPM, 30 PSI shutdown.

(3) Air cell Ambient as close as possible to 77° F.

(4) Coolant outlet temperature 205 ± 5° F, warning 210° F, manual return to idle at 215° F. Cooling system will be pressurized to 12 PSI.

(5) Fuel temperature before pump: 85 ± 5° F.

(6) Exhaust outlet pressure at rated conditions 16 in. H_2O ± 3.

(7) Crankcase pressure maximum 5 in. H_2O.

(8) Nominal fuel flow 200 lb/hr at 2600 RPM.

(9) Exhaust temperature into turbo, 1080° F maximum.

b./ Maintain and record the following adjustments at completion of each 100 hour interval of endurance test or as indicated. Contact test engineer prior to any adjustment.

(1) Idle speed 650 RPM.

(2) Governed speed (no load) 2960 RPM.

(3) Max torque 1030 ft-lb @ 1900 RPM.

(4) Full load 2600 RPM.

5. Engine Instrumentation and Full Load Operational Check-Out.

a. Engine will be run to check leaks, instrumentation, recording and printout systems. The following temperatures and pressures will be maintained:

(1) Inlet air (maintain as close as possible to 77° F)

(2) Air pressure at turbocharger inlet at rated conditions, -5 ± 1 in. H_2O.

(3) Exhaust pressure at turbo outlet at rated conditions, 16 ± 3 in. H_2O.

(4) Coolant outlet temperature $205 \pm 5^{\circ}$ F

(5) Fuel temperature before pump $85 \pm 5^{\circ}$ F

Speeds will be verified after break-in.

b. Full load operational check will be conducted according to the following schedule. During break-in monitor blowby in CFM and/or pressure. Do not continue test if blowby exceeds allowed maximum. Take complete data and record on log sheet for each break-in period. Repeat the cycle down and up.*

Period No.	Time, Minutes	Engine, RPM	Observed BHP	
1	10	650 (Idle)	- -	
2	10	1200	50	217
3	10	1400	100	375
4	10	1600	150	493
5	10	1700	200	610
6	10	1900	250	691
7	20	2100	300	750
8	20	2200	350	836
9	20	2400	400	875
10	20	2500	450	945
11	20	2600	500	1010
12	20	- -	- -	

* Repeat this cycle in a reverse order using same RPM and power values.

c. During period 5 or following period 7, check governor and notify test engineer prior to making adjustments, to limit the maximum speeds as follows:

Full load	2600 RPM
No load (Governed Speed)	2960 RPM

e. During period No.11 the following limits must prevail..

(1)	Oil gallery pressure	30 to 55 PSI
(2)	Exhaust temperature into turbo	1080° F max.
(3)	Crankcase pressure (in. H_2O)	5
(4)	Power output at rated	500 ± 3% at 85°F air inlet, 29.38 in. HG Barometer dry

6. Performance Test (Nominal 500 BHP)

Conduct performance tests with full rack, under the conditions listed in paragraph 4. Record all data listed under instrumentation for engine speeds of 1400 RPM to 2600 RPM at 200 RPM increments. At each setting the engine should be run for a sufficient time for stabilization. Additional tests (part load performance and heat rejection) will be conducted at completion of durability test.

7. Part Load Performance Test (Nominal 500 BHP)

Conduct part load performance tests at 85, 70, 60, 50, 40, 25 and 15 percent loads using speeds of 1400 RPM to 2600 RPM in 100 RPM increments. Paragraph 5 conditions will be maintained during runs. One hundred percent loads will be determined just prior to part load testing. Perform an idle fuel consumption test run with complete printout at the end of part load performance tests.

8. Heat Rejection Tests(Perform at Completion of Durability Test)

Determine heat rejection at full load, 205 ± 5° F, engine coolant out temperature at the following speeds; 1400 RPM to 2600 RPM in 200 RPM increments. Remaining conditions as specified in paragraph 4. (Engine operating limits and adjustments).

9. Four Hundred (400) Hour NATO Endurance Test

a. The 400 hour NATO endurance will be divided into four periods of 100 hours each. Each 100 hour period is to consist of ten (10), ten hour periods as shown in test Schedule A. (New NATO cycle).

TEST SCHEDULE A

Period	Percent Rated Speed	Percent Load	(LB/FT)	Time Hours
1	Idle (650 RPM)	0		1/2
2	100 (2600 RPM)	100	(1010)	2
3	Governed Speed (2960 RPM)	0		1/2
4	75 (1950 RPM)	100		1
5	Idle ⟷ 100	0 ⟷ 100 4 Min. 6 Min.		2
6	60 (1560 RPM)	100		1/2
7	Idle (650 RPM)	0		1/2
8	Governed Speed (2960 RPM)	70	(707)	1/2
9	Max Torque Speed (1900 RPM)	100		2
10	60 (1560 RPM)	50	(505)	1/2
		TOTAL DURATION		10

Conduct 400 hour NATO endurance test according to Test Schedule A. Values of speeds and torques to be provided by test engineer following completion of performance test.

b. During 400 hour endurance, the following pressures and temperatures will be regulated to the values as indicated.

(1) Pressures

(a) Air presure at turbocharger inlet shall be set -5 ± 1 (in. H_2O) at rated conditions and restriction held throughout other tests.

(b) Exhaust outlet pressure at full power through speed range, 13-19 inches H_2O: at idle and part load, 0-13 inches of H_2O.

(2) Temperatures

(a) Inlet air to turbocharger as close as possible to 77° F.

(b) Coolant outlet temperature $205 \pm 5^\circ$ F.

(c) Fuel before secondary filter $85 \pm 5^\circ$ F.

c. Take four ounce oil sample before starting endurance and every 100 hours thereafter, take two ounce oil sample at 25 hour intervals. (Purge oil sample line and take sample from oil gallery with engine idling). Replace the removed sample oil with same amount and type new one.

d. Check engine oil at completion of every five hour test period or before engine is started for a new day of test (whichever occurs first). Allow time for oil to settle before reaching full mark. Do not overfill.

e. Data will be recorded during the last five minutes of each of the ten periods listed in Test Schedule A, and just before stopping engine.

f. The following maintenance and adjustments to engine will be conducted after each 100 hour test period, and before power check. Check with test engineer.

(1) Change oil

(2) Replace oil and fuel filters

(3) Record oil added (less sample) to bring to required level

(4) Maintain adjustments as indicated on page A-5.

(5) Visually inspect engine for leaks, breaks, etc.

g. The 100 hour power check tests shall be conducted under temperature and pressure conditions listed. Record all data listed under "Instrumentation" for engine speeds from 1400 RPM to 2600 RPM in 200 RPM increments, up only. At each setting, the engine should be run for a sufficient time for stabilization. In addition, smoke density samples will be taken at each speed setting.

10. Obtain photographs of engine test set up.

11. Disassembly and Visual Inspection of Engine. Record breaking torques of cylinder head, crankshaft, and connecting rod bolts and photograph parts if required during disassembly. Make components wear measurement.

12. Evaluation of Results and Report.

a. Consolidate and evaluate data.

b. Prepare report.

c. Obtain photographs of set up and engine parts as required.

JOB ASSIGNMENTS:

1. DRSTA-TB will be responsible for gathering data, maintaining a daily log book, and test data log, directing personnel and general execution of test.

2. DRSTA-RGES will be responsible for day to day technical decisions, monitoring test, evaluation of data, and preparing a report.

3. Any changes in the above test program shall be mutually agreed upon by DRSTA-TB and DRSTA-RGES and confirmed by a supplement to this basic test program. Each supplement will be evaluated for potential cost and for schedule revisions.

WRITTEN BY:

16 Nov '82

F. Rostam-Abadi Ext 48537
Project/Test Engineer

REVIEWED AND APPROVED BY:

Roy J. G. Rimpela Ext 48528
Team Leader/Engine Testing

APPENDIX B - FUEL ANALYSIS

ANALYSES OF REFEREE GRADE DIESEL FUEL
(MIL-F-46162B) SAMPLES

Properties	Requirements	#6 Tank AL-12077-F
Density, kg/L at 15°C	Report	0.8655
Gravity, °API	NR (1)	31.9
Distillation, °F (°C)		
Initial boiling point	Report	380 (193)
10% recovered	Report	446 (230)
50% recovered	473-545 (245-285)	514 (268)
90% recovered	626-675 (330-357)	616 (324)
95% recovered	662-707 (350-375)	646 (341)
End point, max	725 (385) max	678 (359)
Sulfur, wt%	0.95-1.05	1.05
Accelerated stability,		
total insolubles, mg/100 mL	1.5 max	1.4
Cetane number	40-45	54
Cetane index	40-45	42
Kinematic viscosity at		
40°C, cSt	1.9-4.1	--
Cloud point, °C	-13 max	--
Particulate contamination,		
mg/L (0.8μm filter)	10 max	2.5
Volume filtered, L	1	1

(1) NR = No requirement
(2) -- = Not measured

APPENDIX C - SAMPLE DATA SHEET

TAPE NO 436
TEST CELL NO 6
OBJECT OF TEST 100% POWER CURVE

U S ARMY TANK AUTOMIVE COMMAND
RESEARCH AND DEVELOPMENT COMMAND
ENGINE CODE NO E-435 ENGINE SERIAL NO 11053470
FUEL MIL-F-46162B (1% SULFUR) OIL MIL-L-2104C (SAE30 IMPERIAL OIL)

TEST ENGINEER R RIMPELA
TEST OBSERVER MASTY

		START						S OW	S OWINS STOP
DATE		1245						1430	1445
TIME		17 MAY 1983							
READING NO		1	2	3	4	5	6	7	
PERIOD NO		1	2	3	4	5	6	7	
TOTAL TEST HOURS	(MUTIPLICATION FACTORS)	200.00							200.00
TOTAL ENGINE HOURS		332.30							334.30
OBSERVED BAROMETER	(HG) 1.356 N.m	29.73	1385.8	1441.4	1431.9	1402.1	1347.8	1273.3	1167.5
TEMP CORRECTION	(HG)	.11							
CORRECTED BAROMETER	(HG) 0.7457 Kw	29.62	377.2	392.5	389.8	293.7	254.1	213.3	171.1
VAPOR PRESSURE	(HG)	.19							
DRY AIR BAROMETER	(HG) 608.3 g/Kw-Hr	29.43	230.5	223.9	~~228.9~~ 217.8	214.7	219.6	229.5	237.8
WET BULB TEMP	(F)	52							
DRY BULB TEMP	(F)	70							
INDICATED ENGINE RPM		FR 2600	FR 2400	FR 2200	FR 2000	FR 1800	FR 1600	FR 1400	
ACTUAL ENGINE RPM		2600	2400	2202	2000	1801	1600	1402	
DYNAMOMETER LOAD (LB FT)	TORQUE	1022 1022	1058 1063	1050 1056	1031 1034	994 994	944 939	853 861	
OBSERVED HP	HORSE PW. 505.9		483.5	442.3	393.8	340.7	286.1	229.5	
CORRECTED HP									
OBSERVED TORQUE									
CORRECTED TORQUE									
FUEL WEIGHT INCREMENT (LB)		30-1 SEC READINGS							
TIME (SEC)		3 MIN AVERAGE							
TIME (SEC)									
CAL FUEL CONS (LBS PER HOUR)		191.883	177.984	158.302	138.983	122.979	106.984	89.796	
FUEL CONS (LBS BHP HR)	BSFC	.379	.368	.358	.353	.361	.394	.391	
TOTAL FUEL CONS (GALS)									
ENGINE OIL ADDED (LBS)		OIL CHANGE							
REFERENCE BATH TEMP (F)		200	200	200	200	199	199	200	
QUARTZ T1 WATER TOWER INLET TEMP	(F)								
QUARTZ T2 WATER TOWER OUTLET TEMP	(F)								
QUARTZ T2-T1 DIFF	(F)								
QUARTZ T1 ENGINE COOLANT INLET	(F)								
QUARTZ T2 ENGINE COOLANT OUTLET	(F)								
QUARTZ T2-T1 DIFF	(F)								
BOSCH SMOKE READING									
BLOWBY (CFM)									
CRANKCASE PR MANOMETER	(H2O)								
HEAT REJECTION DATA									
COOLING WATER	(LBS)								
TIME	(SEC)								
TIME	(SEC)								

Channel	t 131407	t 132653	t 133742	t 134735	t 135725	t 140604	t 141531
10 ENGINE RPM	r 010 + 002601 0	r 010 + 002400 0	r 010 + 002202 0	r 010 + 002001 0	r 010 + 001802 0	r 010 + 001599 0	r 010 + 001401 0
20 DYNAMOTER LOAD	w 020 + [redacted] 1	w 020 + 010637 1	w 020 + 010565 1	w 020 + 010347 1	w 020 + 009948 1	w 020 + 009391 1	w 020 + 008611 1
31 AIR CELL AMB L	j 031 + 007282 2	j 031 + 007642 2	j 031 + 007830 2	j 031 + 007745 2	j 031 + 007793 2	j 031 + 008095 2	j 031 + 007985 2
32 AIR CELL AMB R	j 032 + 009143 2	j 032 + 009145 2	j 032 + 009055 2	j 032 + 009320 2	j 032 + 009012 2	j 032 + 008732 2	j 032 + 008516 2
33 AIR INTO CLEANER	j 033 + [redacted] 2	j 033 + 007375 2	j 033 + 007651 2	j 033 + 007707 2	j 033 + 007615 2	j 033 + 007726 2	j 033 + 007697 2
36 AIR TURBO IN	j 036 + [redacted] 2	j 036 + 007146 2	j 036 + 007384 2	j 036 + 007486 2	j 036 + 007435 2	j 036 + 007626 2	j 036 + 007565 2
37 AIR TURBO OUT (TO AFTERCOLLER)	j 037 + [redacted] 2	j 037 + 027743 2	j 037 + 025294 2	j 037 + 022507 2	j 037 + 019558 2	j 037 + 016972 2	j 037 + 014560 2
38 AIR AFTER COOLER L	j 038 + [redacted] 2	j 038 + 021916 2	j 038 + 021151 2	j 038 + 020311 2	j 038 + 019595 2	j 038 + 019139 2	j 038 + 018845 2
39 AIR AFTER COOLER R	j 039 + [redacted] 2	j 039 + 020910 2	j 039 + 020395 2	j 039 + 019868 2	j 039 + 019406 2	j 039 + 019057 2	j 039 + 018810 2
40 ENGINE OIL GALLERY (MANIFOLD)	j 040 + [redacted] 2	j 040 + 024402 2	j 040 + 024176 2	j 040 + 023940 2	j 040 + 023737 2	j 040 + 023513 2	j 040 + 023221 2
41 OIL SUMP	j 041 + 025786 2	j 041 + 025705 2	j 041 + 025491 2	j 041 + 025243 2	j 041 + 025001 2	j 041 + 024772 2	j 041 + 024537 2
44 FUEL BEFORE PUMP	j 044 + 008364 2	j 044 + 008296 2	j 044 + 008135 2	j 044 + 008218 2	j 044 + 008364 2	j 044 + 008290 2	j 044 + 008334 2
46 FUEL SPILLBACK	j 046 + 013903 2	j 046 + 013875 2	j 046 + 013867 2	j 046 + 014005 2	j 046 + 014235 2	j 046 + 014425 2	j 046 + 014700 2
47 COOLANT ENGINE IN	j 047 + [redacted] 2	j 047 + 019546 2	j 047 + 019503 2	j 047 + 019494 2	j 047 + 019471 2	j 047 + 019432 2	j 047 + 019407 2
48 COOLANT ENGINE OUT	j 048 + 020071 2	j 048 + 020195 2	j 048 + 020159 2	j 048 + 020137 2	j 048 + 020138 2	j 048 + 020139 2	j 048 + 020154 2
49 COOLANT WATER TOWER IN	j 049 + 006004 2	j 049 + 006054 2	j 049 + 006103 2	j 049 + 006124 2	j 049 + 006128 2	j 049 + 006170 2	j 049 + 006193 2
50 COOLANT WATER TOWER OUT	j 050 + [redacted] 2	j 050 + 019501 2	j 050 + 019530 2	j 050 + 019571 2	j 050 + 019608 2	j 050 + 019596 2	j 050 + 019613 2
51 DYNA WATER OUT	j 051 + 012625 2	j 051 + 012506 2	j 051 + 012370 2	j 051 + 012024 2	j 051 + 011749 2	j 051 + 011416 2	j 051 + 010996 2
52 REFERENCE BATH	j 052 + [redacted] 2	j 052 + 020123 2	j 052 + 020122 2	j 052 + 020089 2	j 052 + 020097 2	j 052 + 020140 2	j 052 + 020199 2
53 ENGINE COOLANT B4 THERMOSTAT	j 053 + 020123 2	j 053 + 020274 2	j 053 + 020212 2	j 053 + 020212 2	j 053 + 020218 2	j 053 + 020204 2	j 053 + 020279 2
60 EXHAUST PORT 1R	k 060 + [redacted] 1	k 060 + 011221 1	k 060 + 011251 1	k 060 + 011458 1	k 060 + 011911 1	k 060 + 012299 1	k 060 + 012604 1
61 EXHAUST PORT 2R	k 061 + [redacted] 1	k 061 + 011408 1	k 061 + 011118 1	k 061 + 011133 1	k 061 + 011388 1	k 061 + 011896 1	k 061 + 012642 1
62 EXHAUST PORT 3R	k 062 + [redacted] 1	k 062 + 011049 1	k 062 + 010882 1	k 062 + 010981 1	k 062 + 011382 1	k 062 + 011926 1	k 062 + 012368 1
63 EXHAUST PORT 4R	k 063 + [redacted] 1	k 063 + 009376 1	k 063 + 008933 1	k 063 + 008740 1	k 063 + 008722 1	k 063 + 008780 1	k 063 + 008728 1
64 EXHAUST PORT 1L	k 064 + [redacted] 1	k 064 + 011001 1	k 064 + 010808 1	k 064 + 010948 1	k 064 + 011323 1	k 064 + 011834 1	k 064 + 012302 1
65 EXHAUST PORT 2L	k 065 + [redacted] 1	k 065 + 011265 1	k 065 + 011008 1	k 065 + 011252 1	k 065 + 011571 1	k 065 + 011927 1	k 065 + 012241 1
66 EXHAUST PORT 3L	k 066 + [redacted] 1	k 066 + 011100 1	k 066 + 010874 1	k 066 + 011047 1	k 066 + 011141 1	k 066 + 011421 1	k 066 + 011628 1
67 EXHAUST PORT 4L	k 067 + [redacted] 1	k 067 + 012242 1	k 067 + 011546 1	k 067 + 011271 1	k 067 + 011227 1	k 067 + 011561 1	k 067 + 011559 1
68 EXHAUST B4 TURBO L	k 068 + 012541 1	k 068 + 012181 1	k 068 + 011808 1	k 068 + 011906 1	k 068 + 012353 1	k 068 + 012977 1	k 068 + 013583 1
69 EXHAUST B4 TURBO R	k 069 + 011827 1	k 069 + 011552 1	k 069 + 011432 1	k 069 + 011620 1	k 069 + 012103 1	k 069 + 012661 1	k 069 + 013096 1
70 EXHAUST AFTER TURBO	k 070 + 010084 1	k 070 + 009916 1	k 070 + 009867 1	k 070 + 010219 1	k 070 + 010798 1	k 070 + 011503 1	k 070 + 012107 1
90 AIR TEST CELL (H2O)	l 090 - 005537 4	l 090 - 005531 4	l 090 - 005719 4	l 090 - 005582 4	l 090 - 005699 4	l 090 - 005646 4	l 090 - 005550 4
91 AIR BEFORE TURBO (H2O)	l 091 - 005602 3	l 091 - 005042 3	l 091 - 004069 3	l 091 - 003070 3	l 091 - 002287 3	l 091 - 001690 3	l 091 - 001278 3
92 AIR AFTER TURBO (HG)	u 092 + 036950 3	u 092 + 035707 3	u 092 + 031331 3	u 092 + 025569 3	u 092 + 019503 3	u 092 + 013677 3	u 092 + 008922 3
93 AIR ACROSS FLOW METER (H2O)	l 093 + 000004 3	l 093 + 000006 3	l 093 + 000005 3	l 093 + 000004 3	l 093 + 000003 3	l 093 + 000005 3	l 093 + 000003 3
94 AIR AT FLOW METER (H2O)	l 094 + 000473 3	l 094 + 000471 3	l 094 + 000522 3	l 094 + 000518 3	l 094 + 000519 3	l 094 + 000508 3	l 094 + 000523 3
95 AIR CRANK CASE (H2O)	l 095 + [redacted] 3	l 095 + 003187 3	l 095 + 006980 3	l 095 + 006494 3	l 095 + 005341 3	l 095 + 004751 3	l 095 + 003493 3
96 EXHAUST BEFORE TURBO L (HG)	u 096 + 036650 3	u 096 + 032983 3	u 096 + 026698 3	u 096 + 020291 3	u 096 + 014567 3	u 096 + 009960 3	u 096 + 006424 3
97 EXHAUST BEFORE TURBO R (HG)	u 097 + 034984 3	u 097 + 030946 3	u 097 + 024812 3	u 097 + 018685 3	u 097 + 013144 3	u 097 + 008632 3	u 097 + 005494 3
98 EXHAUST AFTER TURBO (H2O)	j 098 + 001895 2	j 098 + 001447 2	j 098 + 000810 2	j 098 + 000335 2	j 098 + 000117 2	j 098 + 000020 2	j 098 - 000022 2
99 FUEL AT PRI FILTER (PSI)	u 099 - [redacted] 3	u 099 - 005124 3	u 099 - 004047 3	u 099 - 003100 3	u 099 - 002334 3	u 099 - 001642 3	u 099 - 001237 3
100 FUEL RAIL (PSI)	p 100 + [redacted] 2	p 100 + 016079 2	p 100 + 013630 2	p 100 + 011375 2	p 100 + 009329 2	p 100 + 007493 2	p 100 + 005765 2
101 ENGINE OIL GALLERY (PSI)	p 101 + 006895 2	p 101 + 006414 2	p 101 + 005923 2	p 101 + 005276 2	p 101 + 004577 2	p 101 + 003876 2	p 101 + 003185 2
102 COOLANT PUMP OUT (PSI)	p 102 + 002108 2	p 102 + 001957 2	p 102 + 001842 2	p 102 + 001719 2	p 102 + 001616 2	p 102 + 001524 2	p 102 + 001430 2
103 COOLANT PUMP IN (PSI)	p 103 + 012081 3	p 103 + 012186 3	p 103 + 012302 3	p 103 + 012552 3	p 103 + 012627 3	p 103 + 012795 3	p 103 + 012898 3
104 BLOWBY ORIFICE (H2O)	j 105 + 000197 2	j 105 + 000216 2	j 105 + 000189 2	j 105 + 000149 2	j 105 + 000094 2	j 105 + 000049 2	j 105 + 000017 2

APPENDIX D – NATO ENGINE TEST SPECIFICATIONS

NATO STANDARD ENGINE LABORATORY TEST

(GAS TURBINES ENGINES)

AEP-5

EDITION JUNE 80

CHAPTER 1

PURPOSE AND APPLICABILITY

SECTION 1-1. PURPOSE

The purpose of this document is to define a test method and standard conditions to enable all NATO countries to conduct tests using an identical method or to analyse the tests conducted in the laboratories of other NATO countries on the basis of this method.

The method described below is independent of existing national test methods, which may be used for supplementary testing.

When an engine has met the requirements of the tests under the present code, its power rating should be indicated as follows: "Power rating. . .Kw (. . .metric HP) at. . .RPM, in accordance with NATO code AEP 5. Edition June 1980."

SECTION 1-2 APPLICABILITY

These test conditions apply to all service vehicle (combat and transport) propulsion gas turbine engines with free power turbines.

NOTE : SI units will be used.

CHAPTER 2

TEST REQUIREMENTS

SECTION 2-1 - GENERAL COMPOSITION AND ORDER OF TEST

2.1.1. Engine reception.

Running-in in accordance with manufacturer's instructions.

Performance test, complete (full and part loads).

Endurance test.

Performance test, complete (full and part loads).

Disassembly, inspection and measurement.

Report.

NOTES : (1) Engine measurements may be carried out before running-in.

(2) The manufacturer is responsible for defining the running-in programme and the engine should have been run-in before it is submitted for testing.

(3) In so far as possible, the manufacturer's drawings and technical data will be supplied with the engine, to assist inspection and measurement of components.

(4) It is normal practice for the engine to be given a preliminary performance test immediately after receipt, to check acceptability.

(5) The initial, if accomplished, and final inspection of the engine should be carried out by the same inspection team using the same gauges.

2.1.2. During performance and durability testing, the following variables will be monitored :

a - Main values
Speed
Torque (engine output shaft)

b - Ambient conditions
Temperature of ambient air
Atmospheric pressure
Humidity

c - Air and gases
Inlet air temperature
Inlet depression
Inlet air flow (performance test only)
Exhaust temperature
Exhaust back pressure
Gas temperatures at points influencing fuel control (if required)

d - Lubrication and cooling
Oil temperatures and pressures
Temperatures into and out of external coolers
Flow rates of fluids to cooling devices external to the engine (for heat rejection calculations)
Oil consumption (during endurance tests only)

e - Fuel
Fuel temperature
Fuel consumption

f - Miscellaneous
Smoke density
Other parameters which influence fuel control
Vibration

2.1.3. Regulated parameters

Inlet Air Depression * at rated power :
$25 \pm 2,5$ mbar

Exhaust Back Pressure at rated power :
$20 \pm 2,5$ mbar

Fuel Temperature at Fuel Pump Inlet :
$30° C \pm 3° C$

Inlet Air Temperature :
See Section III

* Depression differential between static atmospheric air pressure and the total pressure at the point of measurement.

2.1.4. TEST CONDITIONS

Measuring is to be done in normal and stable operating conditions.

The temperature of the air entering the engine (ambient air) is to be measured at a maximum distance of 0,15 m from the air filter inlet or, if there is no filter, 0,15 m from the air inlet nozzle. The thermometer or thermocouple must be protected against heat radiation and be located directly in the air jet. Testing must be carried out in an adequate number of positions to give a representative inlet temperature.

Once an output speed has been selected for measurement purposes, its value must not vary by more than ± 1 % or ± 10 r.p.m. (whichever of these limits is the higher) during measurement.

The readings for brake load, fuel consumption and inlet air temperature are to be taken simultaneously, the value recorded being the average of two stabilized results, obtained in succession with brake load and fuel consumption differing bv less than 2 %.

When a device fitted with an automatic starting system is used for measuring speed and fuel consumption, the duration of measurement must be at least 30 seconds ; if the measuring device is manually operated, the duration must be at least 60 seconds.

The exhaust gas outlet temperature must be measured at a point downstream and less than 100 mm from the flange (s) of the exhaust manifold (s).

Lubricant temperature is to be measured at the inlet and outlet of the heat exchanger if there is one. Otherwise it must be taken preferably in the lubrication system. The measuring point will be specified in the test report.

Fuel temperature must be read at the fuel pump inlet.

Auxiliary power take-offs may be loaded and measured if desired.

2.1.5. MEASUREMENT ACCURACY

- TORQUE

  The torque must be accurate within ± 0,5 % of the highest value recorded.

- OUTPUT SPEED

  Measurement must be accurate to within ± 0,5 %.

- FUEL CONSUMPTION

  ± 1 % for all apparatus used.

- TEMPERATURES

  Intake air ± 1°C.

- PRESSURE

  Atmospheric pressure ± 0,7 mbar
  Air and gas pressure ± 50 mbar
  Induction and exhaust pressure and depression ± 0,250 mbar
  Pressure of other fluids ± 250 mbar

SECTION 2-2 - DEFINITION OF ENGINE

Engines will be equipped only with such auxiliary equipment as is strictly essential to their operation (see table of auxiliary equipment at Annex A).

SECTION 2-3 - PERFORMANCE TEST

The performance test maximum load curve will be plotted from measurements taken at a minimum of five speed settings, one of these settings being the rated speed.

For each setting, the engine should be run for a sufficient time to allow the operating parameters to stabilize.

Part-load data is to be recorded at the same pre-selected speeds as was used for the full-load test. The part loads for each speed point are to be calculated at least for 85 %, 70 %, 50 % and 25 % of the full load at the given speed.

During this test, the smoke emission as measured on the Robert BOSCH Scale shall not exceed 4.5.

No correction factor will be applied and the test results must include air temperature and atmospheric pressure.

The inlet temperature shall be maintained as close as possible to 25°C.

SECTION 2-4 - ENDURANCE TEST

2.4.1. The endurance test duration is 400 hours, divided into four periods of 100 hours each. At the completion of each period, the engine shall be submitted to a full-load performance check.

During the endurance test, the inlet temperature will be kept as near as possible to 25° C or, when this is not practical, prevailing ambient.

2.4.2. Normal maintenance and adjustment will be permissible after each 100 hour test period.

2.4.3. Engine oil and filters may be changed after each 100 hour period.

2.4.4. The four 100 hour périods which make-up the endurance test are to be carried out with the fuel and lubricant defined in Chapter 3.

2.4.5. Each 100 hour period is to comprise ten 10 hour cycles. Each 10 hour cycle will be carried out in accordance with the programme (section 2.5).

2.4.6. Data will be recorded during the last five minutes of each of the sub-cycles included in the basic 10-hour cycle, with the exception of sub-cycles 3, 4, 7, 8, 10, 11.

2.4.7. No interruptions are permitted during any of the sub-cycles, but the engine may be switched off on completion of any sub-cycle.

2.4.8. One-hundred percent power (load) will be governed by maximum fuel control setting, not adjusted to published maximum power.

SECTION 2-5 - PROGRAMME OF 10 HOUR CYCLE

Period	Rated Speed %	Rated Load %	Duration (hours)
1	Idle (1)	Idle (1)	0,5
2	100	100	1
3	50 ⟷ 100 3 min 3 min	100	1
4	Stop		0,25
5	70	100	1
6	Idle	Idle	0,5
7	Idle ⟷ 100 2 min 3 min	Idle ⟷ 100	2
8	Stop		0,25
9	100	100	1
10	Stop		0,25
11	Idle ⟷ 100 2 min 3 min	Idle ⟷ 100	2
12	Idle	Idle	0,25
		Total	10

At least 5 times during each 100 hour period, the engine will be shut down for a minimum of 6 hours.

(1) Manufacturer's published idle or as specified by vehicle installation.

ANNEX A

DETAILS OF PRODUCTION AUXILIARY EQUIPMENT

Inlet System Air Filter System Inlet Silencer	Optional
Exhaust System Piping Silencer Exhaust Pipes	Test Bench Equipment
Fuel Feed Pump	Optional
Fuel Injection Equipment Prefilter Filter	Yes, or test bench equipment
Electrical Equipment	If necessary

INFORMATION TO BE INCLUDED IN TEST REPORT

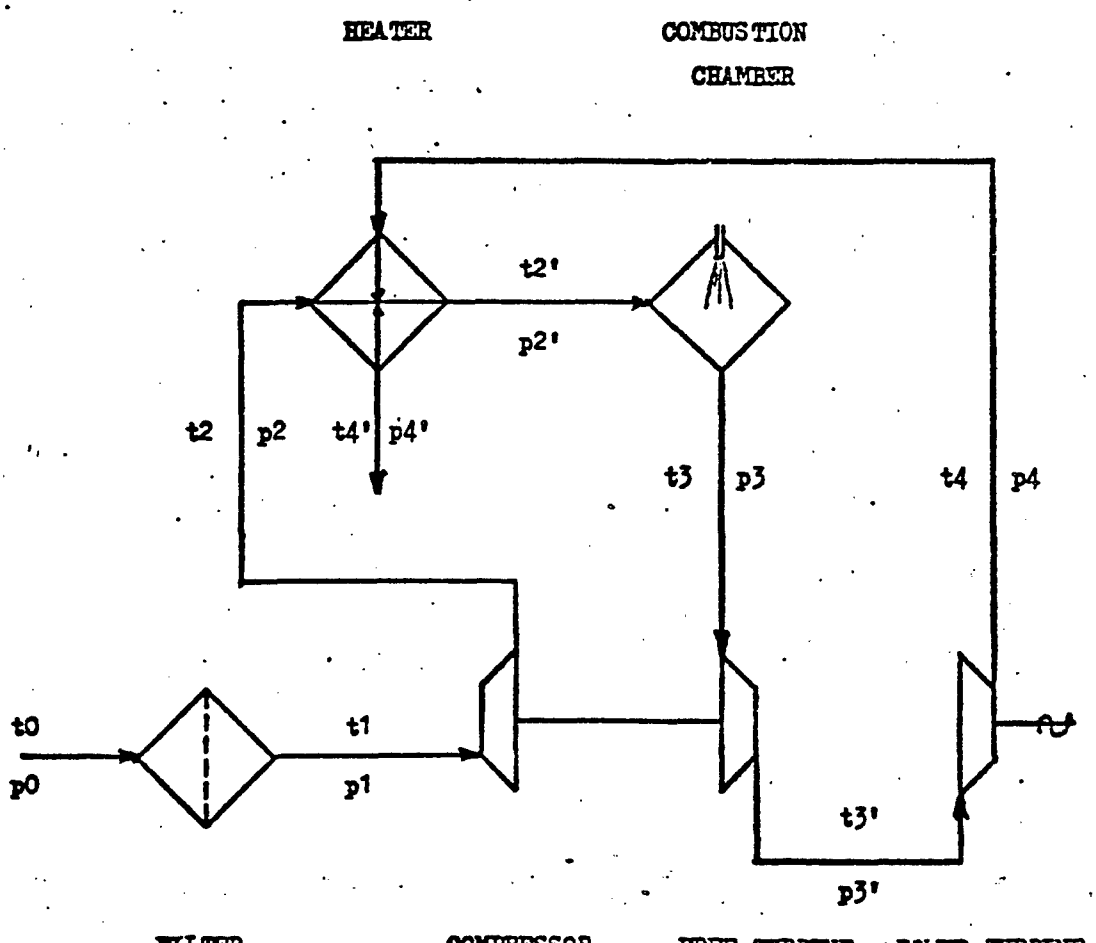
A complete report covering all the tests, servicing, maintenance, rectification of faults and the condition of the engine at the strip examination including the measurements of the principal wearing parts will be compiled.

The report will also include the following :

1. A statement of the build standard of the engine, with drawings and a parts list.
2. Photographs of the engine from four different views.
3. Photographs of the test installation at least four different views.
4. A list of equipment fitted to the engine.
5. Sample test sheets and a summary with a list of faults and the remedial action taken.
6. An engine condition report at end of test with photographs of the condition of major parts such as combustion chamber, compressor wheels and diffusors, turbine wheels and nozzles, reduction gear with any other components of interest.
7. A history chart of lubricating oil used during the endurance tests.
8. Analysis of new and used lubricating oil, the latter to be taken at approximately 100 hours intervals.
9. Fuel analysis.
10. Any other relevant data.

SCHEMATIC DIAGRAM

t0 and p0	:	embiente temperature and pression
t1 and p1	:	temperature and pression after filter
t2 and p2	:	" " after compressor
t2' and p2'	:	" " after heater
t3 and p3	:	" " after combustion chamber
t3' and p3'	:	" " after free turbine
t4 and p4	:	" " after power turbine
t4' and p4'	:	exhaust gas temperature and pression



— air

— gas

NATO STANDARD ENGINE LABORATORY TEST

(DIESEL and GASOLINE ENGINES)

AEP-5

EDITION JUNE 80

CHAPTER 1

PURPOSE AND APPLICABILITY

SECTION 1-1 - PURPOSE

The purpose of this document is to define a test method and standard conditions to enable all NATO countries to conduct tests using an identical method or to analyse the tests conducted in the laboratories of other NATO countries on the basis of this method.

The method described below is independent of existing national test methods, which may be used for supplementary testing.

When an engine has met the requirements of the tests under the present code, its power rating should be indicated as follows : "Power rating .... Kw (... metric HP) at .... r.p.m., in accordance with NATO code AEP 5. Edition June 1980".

SECTION 1-2 - APPLICABILITY

These test conditions apply to all service vehicle (combat and transport) propulsion Diesel and gasoline engines.

NOTE : SI units will be used.

CHAPTER 2

TEST REQUIREMENTS

SECTION 2-1 - GENERAL COMPOSITION AND ORDER OF TEST

2.1.1. Engine reception.

Running-in in accordance with manufacturer's instructions.

Performance test, complete (full and part loads).

Endurance test.

Performance test, complete (full and part loads).

Disassembly, inspection and measurement.

Report.

NOTES : (1) Engine measurements may be carried out before running-in.

(2) The manufacturer is responsible for defining the running-in programme and the engine should have been run-in before it is submitted for testing.

(3) In so far as possible, the manufacturer's drawings and technical data will be supplied with the engine, to assist inspection and measurement of components.

(4) It is normal practice for the engine to be given a preliminary performance test immediately after receipt, to check acceptability.

(5) The initial, if accomplished, and final inspection of the engine should be carried out by the same inspection team using the same gauges.

2.1.2. During performance and durability testing, the following variables will be monitored :

a - Main values
Speed
Torque (engine output shaft)

b - Ambient conditions
Temperature of ambient air
Atmospheric pressure
Humidity

c - Air and gases
Inlet air temperature
Induction or cylinder inlet depression
Inlet air flow (performance test only)
Air temperature and pressure in the inlet manifold
Exhaust temperature
Exhaust back-pressure
Gas temperatures at points influencing fuel control (if required)

d - Lubrication and cooling
Oil temperatures and pressures
Temperatures into and out of external coolers
Flow rates of fluids to cooling devices external to the engine (for heat rejection calculations)
Oil consumption (during endurance tests only)

e - Fuel
Fuel temperature
Fuel consumption

f - Miscellaneous
Blow-by
Smoke density

2.1.3. Regulated parameters

Outlet liquid coolant temperatures :
$96°C \pm 3°C$

Induction depression at rated power :
25 ± 5 mbar

Exhaust back pressure at rated power :
40 mbar $\pm$ 5

Fuel temperature at injection pump inlet :
$30°C \pm 3°C$

2.1.4. TEST CONDITIONS

Measuring is to be done in normal and stable operating conditions.

The temperature of the air entering the engine (ambient air) is to be measured at a maximum distance of 0,15 m from the air filter inlet or, if there is no filter, 0,15 m from the air inlet nozzle. The thermometer or thermocouple must be protected against heat radiation and be located directly in the air jet. Testing must be carried out in an adequate number of positions to give a representative inlet temperature.

Once an output speed has been selected for measurement purposes, its value must not vary by more than ± 1 % or ± 10 r.p.m. (whichever of these limits is the higher) during measurement.

The readings for brake load, fuel consumption and inlet air temperature are to be taken simultaneously, the value recorded being the average of two stabilized results, obtained in succession with brake load and fuel consumption differing by less than 2 %.

When a device fitted with an automatic starting system is used for measuring speed and consumption, the duration of measurement must be at least 30 seconds ; if the measuring device is manually operated, the duration must be at least 60 seconds.

The exhaust gas outlet temperature must be measured at a point downstream and less than 100 mm from the flange (s) of the exhaust manifold (s).

Lubricant temperature is to be measured at the inlet and outlet of the heat exchanger if there is one. Otherwise it must be take preferably in the lubrication system, or, failing this, in the crank case. The measuring point will be specified in the test report.

Fuel temperature must be read at the injection pump inlet, or carburettor inlet.

Cooling condition for air cooled engine will be in accordance with manufacturers specification.

Auxiliary power take-offs may be loaded and mesured if desired

2.1.5. MEASUREMENT ACCURACY

- TORQUE

  The torque must be accurate within ± 0,5 % of the highest value to be measured.

- OUTPUT SPEED

  Measurement must be accurate to within ± 0,5 %.

- FUEL CONSUMPTION

  ± 1 % for all apparatus used.

- TEMPERATURES

  Intake air ± 1°C.

- PRESSURE

  Atmospheric pressure ± 0.7 mbar
  Air and gas pressure ± 50 mbar
  Induction and exhaust pressure and depression ± 0,250 mbar
  Pressure of other fluids ± 250 mbar

SECTION 2-2 - DEFINITION OF ENGINE

Engines will be equipped only with such auxiliary equipment as is strictly essential to their operation (see table of auxiliary equipment at Annex A).

SECTION 2-3 - PERFORMANCE TEST

The performance test maximum load curve will be plotted from measurements taken at a minimum of five speed settings, the fifth setting being the rated speed.

For each setting, the engine should be run for a sufficient time to allow the operating parameters to stabilize.

Part-load data is to be recorded at the same pre-selected speed as was used for the full-load test. The part loads for each speed point are to be calculated at least for 85 %, 70 %, 50 % and 25 % of the full load at the given speed.

During this test, the smoke emission as measured on the Robert BOSCH Scale (or equivalent) shall not exceed 4.5.

No correction factor will be applied and the test results must include air temperature and atmospheric pressure.

The inlet air temperature shall be maintained as close as possible to 25°C.

SECTION 2-4 - ENDURANCE TEST

2.4.1. The endurance test duration is 400 hours, divided into four periods of 100 hours each. At the completion of each period, the engine shall be submitted to a full-load performance check.

2.4.2. Normal maintenance and adjustment will be permissible after each 100 hour test period.

2.4.3. Engine oil and filters shall be changed after each 100 hour period.

2.4.4. The coolant outlet temperature is to be held at 96°C ± 3°C or a higher temperature if proposed by the manufacturer. The coolant is to be water plus antifreeze in egal volume.

2.4.5. The engine oil temperature is to be measured in the lubrication system. The temperature measurement location shall be specified.

2.4.6. The four 100 hour periods which make up the endurance test are to be carried out with the reference fuel defined in Chapter 3.

2.4.7. Each 100 hour period is to comprise ten 10 hour cycles. Each 10 hour cycle will be carried out in accordance with the programme (section 2-5).

2.4.8. Data will be recorded during the last five minutes of each of the sub-cycles included in the basic 10 hours cycle, with the exception of sub-cycle 5.

2.4.9. No interruptions are permitted during any of the sub-cycles, but the engine may be switched off on completion of any sub-cycle.

SECTION 2-5 - PROGRAMME OF 10 HOUR CYCLE

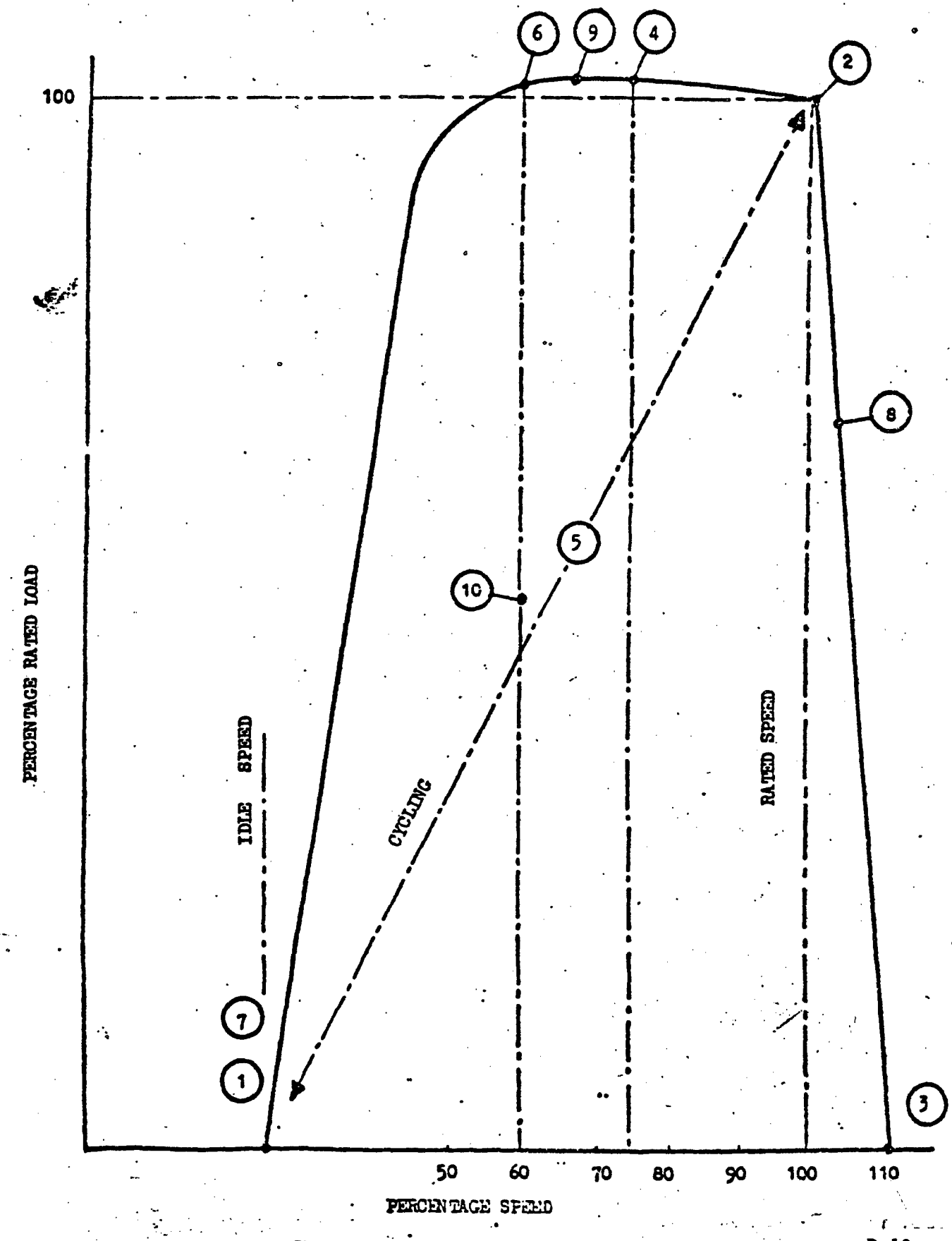
Sub Cycle	% Rated Speed	% Load (3)	Duration in hours
1	IDLE	0	½
2	100	100	2
3	governed speed (1)	0	½
4	75	100	1
5	IDLE ⟷ 100	0 ⟷ 100 4 MIN 6 MIN	2
6	60	100	½
7	IDLE	0	½
8	governed speed (2)	70 (3)	½
9	Max torque speed	100	2
10	60	50 (3)	½
		Total	10

NOTES :

(1) The speed shall be that attained with the engine at full throttle and with minimum load (residual brake load).

(2) The speed shall be the steady speed of the engine at full throttle and 70 % load.

(3) Part loads (70 and 50 %) shall be taken from the initial performance test.


100
PERCENTAGE RATED LOAD
IDLE SPEED
CYCLING
RATED SPEED
50
60
70
80
90
100
110
PERCENTAGE SPEED
1
2
3
4
5
6
7
8
9
10

CHAPTER 3

FUELS AND LUBRICANTS AND ANTIFREEZES

301 Engines are to be tested on Reference Fuels and Lubricants and antifreezes as specified by the relevant NATO Authority.

CHAPTER 4

DEFINITION OF TEST FAILURE

401 A major failure is a failure of any part or component of the engine assembly that leads to a final stoppage of the test or that brings about as loss of power which cannot be rectified to give at least 95 % of rated power.

Any major failure will lead to termination of the test and any retest must start at 0 hour.

Major failures and corrective action are to be reported to the proper National Authority.

402 A minor failure is a defect which leads to a loss of power or degradation of the operation of the engine and which it is possible to remedy within the scope of normal maintenance and adjustment. If 95 % of the rated power cannot be obtained after normal maintenance then the test will be terminated. The minor failures and the measures taken to overcome them must be included in the report.

403 The suitability of an engine for NATO AEP5 Approval is to be the responsibility of the National Authorities after completion of the 400 hours test and consideration of the final condition of the engine.

ANNEXE A

DETAILS OF PRODUCTION AUXILIARY EQUIPMENT

(To be included as applicable)

Inlet system	
Inlet manifold	Yes
Air filter	Optional
Inlet silencer	
Blowby gas recirculation intake ...	
Exhaust system	
Manifold	Yes
Piping	Test bench equipment
Silencer	
Exhaust pipes	
Fuel feed pump	Yes
Carburettor	Yes (details of adjustment will be specified)
Ignition system	
Distributor	Yes
Spark-plugs	Yes
Coils	Yes
Suppressor	Yes
Fuel injection equipment	
Prefilter	Yes or test bench equipment
Filter	
Pump	Yes
High-pressure pipes	Yes
Injector	Yes

Liquid cooling equipment	
Radiator ..... }	No
Fan ..... }	
Water pump	Yes
Thermostat	Yes
Air cooling equipment	
Streamlining	Yes
Blower	Yes
Temperature regulating device	Yes
Electrical equipment	If necessary
Supercharging equipment	
Compressor driven directly or indirectly by the engine and/or exhaust gas	Yes
Charge cooler	Yes
Cooling pump or fan ..... (engine driven)	Yes
Device for regulating flow of cooling fluid	Yes

ANNEX B

INFORMATION TO BE INCLUDED

IN TEST REPORT

A complete report covering all the tests, servicing, maintenance, rectification of faults and the condition of the engine at the strip examination including the measurements of the principal wearing parts will be compiled.

The report will also include the following :

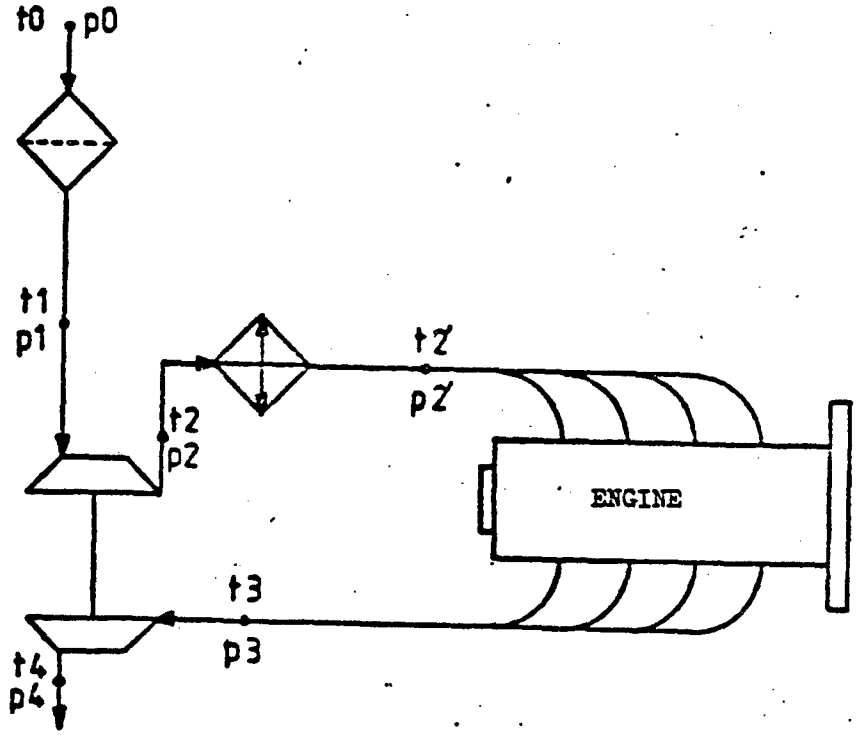
1. A statement of the build standard of the engine, with drawings and a parts list.
2. Photographs of the engine from four different views.
3. Photographs of the test installation at least four different views.
4. A list of equipment fitted to the engine.
5. Sample test sheets and a summary with a list of faults and the remedial action taken.
   Full load performance data will be show in the format indicated.
6. An engine condition report at end of test with photographs of the condition of major parts such as pistons, bearings, valves, camshafts, crankshafts, cylinder bores together with any other components of interest.
7. A history chart of lubricating oil used during the endurance tests.
8. Analysis of new and used lubricating oil, the latter to be taken at approximately 100 hours intervals.
9. Fuel analysis.
10. Any other relevant data.

ENGINE Type:	N°:	Place date:
FULL CHARGE PERFORMANCES INITIAL ☐ FINAL ☐		Reference:
FUEL:	OIL type:	BRAKE type:
Volume mass: kg/dm³	grade:..	

AMBIENT	t0	°C									
	p0	mbar									
PERFORMANCE	n	r.p.m									
	M	m.daN									
	p	kw									
	pme	bar									
FUEL	Cs/bsfc	g/kw.h									
	Qc	mm^3_{cycle}									
	qm	kg./h									
OIL	tH	°C									
	pH	bar									
WATER	te	°C									
	ts	°C									
INLET	t1	°C									
	p0 - p1	mbar									
	t2	°C									
	p2	bar									
	t2'	°C									
	p2 - p2'	mbar									
EXHAUST	t3	°C									
	p3	bar									
	t4	°C									
	p4 - p0	mbar									
	Smoke	Bosch									
BLOW - BY		cm^3/mn									

DEFINITION OF SHORTS

- t0 : ambient temperature
- p0 : ambient pressure
- n : engine speed
- M : engine torque
- P : output power
- pme/bmep: brake mean effective pressure
- Cs/bsfc : specific fuel consumption
- Qc : volume of fuel per injection
- qm : mass fuel flow per hour
- tH : oil temperature
- pH : oil pressure
- te : coolant temperature into engine
- ts : coolant temperature out of engine
- t1 : air temperature after filter (or compressor inlet)
- p0 - p1 : inlet depression
- t2 : compressor discharge temperature
- p2 : compressor discharge pressure
- t2' : air temperature after charge cooler
- p2 - p2' : pressure of across charge cooler
- t3 : exhaust gaz temperature (turbine inlet)
- p3 : exhaust gaz pressure (turbine inlet)
- t4 : turbine discharge temperature
- p4 - p0 : Exhaust back pressure



APPENDIX E

LUBE OIL SPECTROGRAPHIC ANALYSIS

Send to this address

OIL ANALYSIS REQUEST

KEYPUNCH CODE

		KEYPUNCH CODE
TO	OIL ANALYSIS LAB: New Cumberland STSGP-PE	1-3
FROM	MAJOR COMMAND: TACOM, Warren, MI 48090	4
FROM	OPERATING ACTIVITY (Include ZIP Code/APO) DODAAD: DRSTA-RGRD Mr. R. Rimpela Warren, Michigan 48090 AVN: 786-8528	5-10
	EQUIPMENT MODEL/AN: Cummins VTA-903 Engine	11-14
	EQUIPMENT SER. NO.	15-20
	END ITEM MODEL/HULL NO.	
	END ITEM SER. NO./EIC	
	DATE SAMPLE TAKEN (Day, Mo., Yr) / LOCAL TIME SAMPLE TAKEN	21-24
	HOURS/MILES SINCE OVERHAUL: 400 Hour NATO Test	25-29
	HOURS/MILES SINCE OIL CHANGE	30-33
	REASON FOR SAMPLE: ☐ ROUTINE ☐ LAB REQUEST ☐ TEST CELL ☐ OTHER (Specify)	34
	OIL ADDED SINCE LAST SAMPLE (Pts, Qts, Gals)	35-36
	ACTION TAKEN: SAMPLE - 5	
	DISCREPANT ITEM: TAKEN AT 126.5 HRS	
	HOW MALFUNCTIONED: OF ENDURANCE	
	HOW FOUND: ☐ LAB REQUEST ☐ AIR OR GROUND CREW	
	HOW TAKEN: ☐ DRAIN ☐ TUBE / SAMPLE TEMPERATURE: ☑ HOT ☐ COLD / TYPE OIL: MIL-L-2104C (30)	

REMARKS: Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance.

2/6

FOR LAB USE ONLY

SAMPLE RESPONSE TIME						
						39-40
FE 41-43	AG 44-46	AL 47-49	CR 50-52	CU 53-55	MG 56-58	NI 59-61
23	0	0	6	6	809	2
PB 62-64	SI 65-67	SN 68-70	TI 71-73	MO 74-76		
14	4	2	0	1		
LAB RECOMMENDATION						77-78
SAMPLE NO. [redacted]173		NATURE		FILE MAINT 79		DATA SEQ 80

DD FORM 1 NOV 77 2026 PREVIOUS EDITION WILL BE USED

OIL ANALYSIS REQUEST		KEYPUNCH CODE
TO	OIL ANALYSIS LAB New Cumberland STSCP-PE	1-3
FROM	MAJOR COMMAND TACOM, Warren, MI 48090	4
FROM	OPERATING ACTIVITY (Include ZIP Code/APO) DODAAD DRSTA-RGRD Mr. R. Rimpela Warren, Michigan 48090 AVN: 786-8528	5-10
EQUIPMENT MODEL/ANL Cummins VTA-903 Engine		11-14
EQUIPMENT SER. NO.		15-20
END ITEM MODEL/HULL NO.		
END ITEM SER. NO./EIC		
DATE SAMPLE TAKEN (Day, Mo., Yr)	LOCAL TIME SAMPLE TAKEN	21-24
HOURS/MILES SINCE OVERHAUL 400 Hour NATO Test		25-29
HOURS/MILES SINCE OIL CHANGE		30-33
REASON FOR SAMPLE ☐ ROUTINE ☐ LAB REQUEST ☐ TEST CELL ☐ OTHER (Specify)		34
OIL ADDED SINCE LAST SAMPLE (Pts, Qts, Gals)		
ACTION TAKEN SAMPLE(S) TAKEN AT		
DISCREPANT ITEM 150 HOURS OF ENDURANCE		
HOW MALFUNCTIONED		
HOW FOUND ☐ LAB REQUEST ☐ AIR OR GROUND CREW		
HOW TAKEN ☐ DRAIN ☐ TUBE	SAMPLE TEMPERATURE ☑ HOT ☐ COLD	TYPE OIL MIL-2104C (30WT) 37-38

REMARKS Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance.

FOR LAB USE ONLY

SAMPLE RESPONSE TIME						39-40
FE 41-43	AG 44-46	AL 47-49	CR 50-52	CU 53-55	MG 56-58	NI 59-61
34	0	0	7	8	922	3
PB 62-64	SI 65-67	SN 68-70	TI 71-73	MO 74-76		
21	4	0	0	2		
LAB RECOMMENDATION						77-78

SAMPLE NO.	SIGNATURE	FILE MAINT 79	DATA SEQ 80
138			

DD FORM 1 NOV 77 2026 PREVIOUS EDITION WILL BE USED

OIL ANALYSIS REQUEST		KEYPUNCH CODE
TO	OIL ANALYSIS LAB New Cumberland STSCP-PE	1-3
FROM	MAJOR COMMAND TACOM, Warren, MI 48090	4
FROM	OPERATING ACTIVITY (Include ZIP Code/APO/FPO/AAD) DRSTA-RGRD Mr. R. Rimpela Warren, Michigan 48090 AVN: 786-8528	5-10
EQUIPMENT MODEL/AFL Cummins VTA-903 Engine		11-14
EQUIPMENT SER. NO.		15-20
END ITEM MODEL/HULL NO.		
END ITEM SER. NO./EIC		
DATE SAMPLE TAKEN (Day, Mo, Yr)	LOCAL TIME SAMPLE TAKEN	21-24
HOURS/MILES SINCE OVERHAUL 400 Hour NATO Test		25-29
HOURS/MILES SINCE OIL CHANGE		30-33
REASON FOR SAMPLE ☐ ROUTINE ☐ LAB REQUEST ☐ TEST CELL ☐ OTHER (Specify)		34
OIL ADDED SINCE LAST SAMPLE (Pts, Qts, Gals)		35-36
ACTION ITEM SAMPLE 7 TAKEN AT		
DISCREPANT ITEM 176.5 HOURS OF		
HOW MALFUNCTION ENDURANCE		
HOW FOUND ☐ LAB REQUEST ☐ AIR OR GROUND CREW		
HOW TAKEN ☐ DRAIN ☐ TUBE	SAMPLE TEMPERATURE ☑ HOT ☐ COLD	TYPE OIL MIL-2104C (30wt) 37-38

REMARKS Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance. 231

FOR LAB USE ONLY

SAMPLE RESPONSE TIME						39-40
FE 41-43	AG 44-46	AL 47-49	CR 50-52	CU 53-55	MG 56-58	NI 59-61
48	0	0	10	11	934	3
PB 62-64	SI 65-67	SN 68-70	TI 71-73	MO 74-76		
30	4	11	0	0		
LAB RECOMMENDATION						77-78

SAMPLE NO. 130	SIGNATURE	FILE MAINT 79	DATA SEQ 80

DD FORM 1 NOV 77 2026 PREVIOUS EDITION WILL BE USED

OIL ANALYSIS REQUEST		KEYPUNCH CODE
TO	OIL ANALYSIS LAB: New Cumberland STSGP-PE	1-3
FROM	MAJOR COMMAND: TACOM, Warren, MI 48090	4
FROM	OPERATING ACTIVITY (Include ZIP Code/APO) DODAAD: DRSTA-RGRD Mr. R. Rimpela Warren, Michigan 48090 AVN: 786-8528	5-10
EQUIPMENT MODEL/APL: Cummins VTA-903 Engine		11-14
EQUIPMENT SER. NO.		15-20
END ITEM MODEL/HULL NO.		
END ITEM SER. NO./EIC		
DATE SAMPLE TAKEN (Day, Mo., Yr)	LOCAL TIME SAMPLE TAKEN	21-24
HOURS/MILES SINCE OVERHAUL: 400 Hour NATO Test		25-29
HOURS/MILES SINCE OIL CHANGE		30 33
REASON FOR SAMPLE: ☐ ROUTINE ☐ LAB REQUEST ☐ TEST CELL ☐ OTHER (Specify)		34
OIL ADDED SINCE LAST SAMPLE (Pts, Qts, Gals)		35-38
ACTION TAKEN: SAMPLE 8 TAKEN AT 200 HRS OF ENDURANCE		
DISCREPANCY REF		
HOW MALFUNCTIONED		
HOW FOUND: ☐ LAB REQUEST ☐ AIR OR GROUND CREW		
HOW TAKEN: ☐ DRAIN ☐ TUBE	SAMPLE TEMPERATURE: ☑ HOT ☐ COLD	TYPE OIL: MIL-2104C (30wt.)

REMARKS: Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance. 237/2

FOR LAB USE ONLY

SAMPLE RESPONSE TIME						
						39-40
FE 41-43	AG 44-46	AL 47-49	CR 50-52	CU 53-55	MG 56-58	NI 59-61
63	0	0	12	16	948	3
PB 62-64	SI 65-67	SN 68-70	TI 71-73	MO 74-76		
40	5	0	0	0		
LAB RECOMMENDATION						77-78
SAMPLE NO. 80	SIGNATURE		FILE MAINT 79			DATA SEQ 80

DD FORM 1 NOV 77 2026 PREVIOUS EDITION WILL BE USED

)

OIL ANALYSIS

SAMPLE 5 TAKEN AT 126.5 HRS.

AL	BURN AND PRINT							
AP	TYPE	COMP	SER	NUMBER	DATE	TRANSIT	OSOH	OSOC	SAMPLE
NG		36.9	LIH	0177	3153	00	0127	000	T

FE	AG	AL	BE	CR	CU	MG	NA	NI	PB	SI	SN	TI	B	BA	CD	MN	MO	V	ZN
023	000	000	000	006	006	809	002	002	014	004	002	000	183	000	000	002	001	022	421

SAMPLE 6 TAKEN AT 150 HRS.

LOCAL	BURN AND PRINT							
COMP	TYPE	COMP	SER	NUMBER	DATE	TRANSIT	OSOH	OSOC	SAMPLE
DENG		36.9	LIH	0178	3153	00	0150	000	T

FE	AG	AL	BE	CR	CU	MG	NA	NI	PB	SI	SN	TI	B	BA	CD	MN	MO	V	ZN
034	000	000	000	007	008	922	002	003	021	004	000	000	169	000	000	000	002	011	512
6																			

SAMPLE 7 TAKEN AT 176.5 HOURS

LOCAL	BURN AND PRINT							
COMP	TYPE	COMP	SER	NUMBER	DATE	TRANSIT	OSOH	OSOC	SAMPLE
DENG		36.9	LIH	0179	3153	00	0177	000	T

FE	AG	AL	BE	CR	CU	MG	NA	NI	PB	SI	SN	TI	B	BA	CD	MN	MO	V	ZN
048	000	000	000	010	011	934	003	003	030	004	011	000	150	000	000	000	000	024	500
4																			

SAMPLE 8 TAKEN AT 200 HRS

LOCAL	BURN AND PRINT							
COMP	TYPE	COMP	SER	NUMBER	DATE	TRANSIT	OSOH	OSOC	SAMPLE
DENG		36.9	LIH	0180	3153	00	0200	000	T

FE	AG	AL	BE	CR	CU	MG	NA	NI	PB	SI	SN	TI	B	BA	CD	MN	MO	V	ZN
063	000	000	000	012	016	948	003	003	040	005	000	000	127	000	000	002	000	024	438

OIL ANALYSIS REQUEST		KEYPUNCH CODE
TO	OIL ANALYSIS LAB New Cumberland STSGP-PE	1-3
FROM	MAJOR COMMAND TACOM, Warren, MI 48090	4
FROM	OPERATING ACTIVITY (Include ZIP Code/APO) DODAAD DRSTA-RGRD Mr. R. Rimpela Warren, Michigan 48090 AVN: 786-8528	5-10
EQUIPMENT MODEL (AR) Cummins VTA-903 Engine		11-14
EQUIPMENT SER. NO.		15-20
END ITEM MODEL/HULL NO.		
END ITEM SER. NO./EIC		
DATE SAMPLE TAKEN (Day, Mo., Yr)	LOCAL TIME SAMPLE TAKEN	21-24
HOURS/MILES SINCE OVERHAUL 400 Hour NATO Test		25-29
HOURS/MILES SINCE OIL CHANGE		30-34
REASON FOR SAMPLE ☐ ROUTINE ☐ LAB REQUEST ☐ TEST CELL ☐ OTHER (Specify)		34
OIL ADDED SINCE LAST SAMPLE (Pts, Qts, Gals)		35-36
ACTION TAKEN SAMPLE - 9		
END ITEM MILEAGE TAKEN AT 226.5 HOURS OF		
HOW MALFUNCTIONED ENDURANCE		
HOW FOUND ☐ LAB REQUEST ☐ AIR OR GROUND CREW		
HOW TAKEN ☐ DRAIN ☐ TUBE	SAMPLE TEMPERATURE ☒ HOT ☐ COLD	TYPE OIL 37-38 MIL-L-2104C (30 wt)

REMARKS Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance.

FOR LAB USE ONLY

SAMPLE RESPONSE TIME						39-40
FE 41-43	AG 44-45	AL 47-49	CR 50-52	CU 53-55	MG 56-58	NI 59-61
21	0	2	6	6	700	3
PB 62-64	SI 65-67	SN 68-70	TI 71-73	MO 74-76		
10	3	0	0	3		
LAB RECOMMENDATION						77-78
SAMPLE NO. 161	SIGNATURE		FILE MAINT 79			DATA SEQ 80

DD FORM 1 NOV 77 2026 PREVIOUS EDITION WILL BE USED

OIL ANALYSIS REQUEST			KEYPUNCH CODE
TO	OIL ANALYSIS LAB New Cumberland STSGP-PE		1-3
FROM	MAJOR COMMAND TACOM, Warren, MI 48090		4
FROM	OPERATING ACTIVITY (Include ZIP Code/APO) DODAAD DRSTA-RGRD Mr. R. Rimpela Warren, Michigan 48090 AVN: 786-8528		5 10
EQUIPMENT MODEL/ARL Cummins VTA-903 Engine			11-14
EQUIPMENT SER NO.			15-20
END ITEM MODEL/HULL NO.			
END ITEM SER NO/EIC			
OIL SAMPLE TAKEN (Day, Mo., Yr)	LOCAL TIME SAMPLE TAKEN		21-24
HOURS/MILES SINCE OVERHAUL 400 Hour NATO Test			25-29
HOURS/MILES SINCE OIL CHANGE			30-33
REASON FOR SAMPLE ☐ ROUTINE ☐ LAB REQUEST ☐ TEST CELL ☐ OTHER (Specify)			34
OIL ADDED SINCE LAST SAMPLE (Pts, Qts, Gals)			35-36
ACTION TAKEN SAMPLE 10			
TAKEN AT 250 Hrs OF			
HOW MALFUNCTIONED ENDURANCE			
HOW FOUND ☐ LAB REQUEST ☐ AIR OR GROUND CREW			
HOW TAKEN ☐ DRAIN ☐ TUBE	SAMPLE TEMPERATURE ☒ HOT ☐ COLD	TYPE OIL (MIL-L-2104C- 30wt)	37-38

REMARKS Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance.

FOR LAB USE ONLY

SAMPLE RESPONSE TIME						39-40
	228/72					
FE 41-43	AG 44-46	AL 47-49	CR 50-52	CU 53-55	MG 56-58	NI 59-61
27	0	2	7	7	755	3
PB 62-64	SI 65-67	SN 68-70	TI 71-73	MO 74-76		
11	3	6	0	3		
LAB RECOMMENDATION						77-78

SAMPLE NO.	SIGNATURE	FILE MAINT 79	DATA SEQ 80
100			

DD FORM 1 NOV 77 2026 PREVIOUS EDITION WILL BE USED

OIL ANALYSIS REQUEST		KEYPUNCH CODE
TO	OIL ANALYSIS LAB: New Cumberland STSGP-PE	1-3
FROM	MAJOR COMMAND: TACOM, Warren, MI 48090	4
FROM	OPERATING ACTIVITY (Include Zip Code/APO) HODAAD: DRSTA-RGRD Mr. R. Rimpela Warren, Michigan 48090 AVN: 786-8528	5-10
EQUIPMENT MODEL/APL: Cummins VTA-903 Engine		11-14
EQUIPMENT SER. NO.		15-20
END ITEM MODEL/HULL NO.		
END ITEM SER. NO./EIC		
DATE SAMPLE TAKEN (Day, Mo., Yr)	LOCAL TIME SAMPLE TAKEN	21-24
HOURS/MILES SINCE OVERHAUL: 400 Hour NATO Test		25-29
HOURS/MILES SINCE OIL CHANGE		30-33
REASON FOR SAMPLE: ☐ ROUTINE ☐ LAB REQUEST ☐ TEST CELL ☐ OTHER (Specify)		34
OIL ADDED SINCE LAST SAMPLE (Pts, Qts, Gals)		35-36
ACCESSORIES		
DISCREPANCY ITEM		
HOW MALFUNCTIONED: SAMPLE 11 TAKEN AT 276.5 HRS OF ENDURANCE		
HOW FOUND: ☐ LAB REQUEST ☐ AIR OR GROUND CREW		
HOW TAKEN: ☐ DRAIN ☐ TUBE	SAMPLE TEMPERATURE: ☒ HOT ☐ COLD	TYPE OIL: MIL-L-2104C (9W 30) 37

REMARKS: Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance.

FOR LAB USE ONLY

SAMPLE RESPONSE TIME						39-40
FE 41-43	AG 44-46	AL 47-49	CR 50-52	CU 53-55	MG 56-58	NI 59-61
36	0	4	10	10	638	3
PB 62-64	SI 65-67	SN 68-70	TI 71-73	MO 74-76		
17	4	19	0	4		
LAB RECOMMENDATION						77-78

SAMPLE NO.	SIGNATURE	FILE MAINT 79	DATA SEQ 80
98			

DD FORM 1 NOV 77 2026 PREVIOUS EDITION WILL BE USED

OIL ANALYSIS REQUEST		KEYPUNCH CODE
TO	OIL ANALYSIS LAB New Cumberland STSGP-PE	1-3
FROM	MAJOR COMMAND TACOM, Warren, MI 48090	4
FROM	OPERATING ACTIVITY (Include ZIP Code/APO) DODAAD DRSTA-RGRD Mr. R. Rimpela Warren, Michigan 48090 AVN: 786-8528	5-10
EQUIPMENT MODEL/AN Cummins VTA-903 Engine		11-14
EQUIPMENT SER. NO.		15-20
END ITEM MODEL/HULL NO.		
END ITEM SER. NO./EIC		
DATE SAMPLE TAKEN (Day, Mo., Yr)	LOCAL TIME SAMPLE TAKEN	21-24
HOURS/MILES SINCE OVERHAUL 400 Hour NATO Test		25-29
HOURS/MILES SINCE OIL CHANGE		30-33
REASON FOR SAMPLE ☐ ROUTINE ☐ LAB REQUEST ☐ TEST CELL ☐ OTHER (Specify)		34-37
OIL ADDED SINCE LAST SAMPLE (Pts, Qts, Gals) NO		35-38
ACTION TAKEN SAMPLE 12		
TAKEN AT 300 HOURS		
OF ENDURANCE		
HOW FOUND ☐ LAB REQUEST ☐ AIR OR GROUND CREW		
HOW TAKEN ☐ DRAIN ☐ TUBE	SAMPLE TEMPERATURE ☒ HOT ☐ COLD	TYPE OIL MIL-L-2104C (30wt) 32-36

REMARKS Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance.

FOR LAB USE ONLY

SAMPLE RESPONSE TIME						39-40
FE 41-43	AG 44-46	AL 47-49	CR 50-52	CU 53-55	MG 56-58	NI 59-61
52	0	4	11	13	800	3
PB 62-64	SI 65-67	SN 68-70	TI 71-73	MO 74-76		
24	4	0	0	3		
LAB RECOMMENDATION						77-78

SAMPLE NO. 99	SIGNATURE	FILE MAINT 79	DATA SEQ 80

DD FORM 1 NOV 77 2026 PREVIOUS EDITION WILL BE USED

UTJ8Z

COMP TYPE	COMP SER	NUMBER	DATE	TRANSIT	OSOH	OSOC	SAMPLE
DENG	VTA903	0098	3174	33	0000	276	F

SAMPLE 11 TAKEN AT 276.5 HRS

FE	AG	AL	BE	CR	CU	MG	NA	NI	PB	SI	SN	TI	B	BA	CD	MN	MO	V	ZN
036	000	004	000	010	010	638	004	003	017	004	019	000	099	000	000	000	004	014	013

UTJ8Z

COMP TYPE	COMP SER	NUMBER	DATE	TRANSIT	OSOH	OSOC	SAMPLE
DENG	VTA903	0099	3174	33	0000	300	F

SAMPLE 12 TAKEN AT 300 HRS

FE	AG	AL	BE	CR	CU	MG	NA	NI	PB	SI	SN	TI	B	BA	CD	MN	MO	V	ZN
052	000	004	000	011	013	800	004	003	024	004	000	000	090	000	000	000	003	006	029

UTJ8Z

COMP TYPE	COMP SER	NUMBER	DATE	TRANSIT	OSOH	OSOC	SAMPLE
DENG	VTA903	0100	3174	33	0000	250	F

SAMPLE 10 TAKEN AT 250 HRS

FE	AG	AL	BE	CR	CU	MG	NA	NI	PB	SI	SN	TI	B	BA	CD	MN	MO	V	ZN
027	000	002	000	007	007	755	003	003	011	003	006	000	127	000	000	000	003	013	026
T																			

UTJ8Z

COMP TYPE	COMP SER	NUMBER	DATE	TRANSIT	OSOH	OSOC	SAMPLE
DENG	VTA903	0101	3174	33	0000	226	F

SAMPLE 9 TAKEN AT 226.5 HRS

FE	AG	AL	BE	CR	CU	MG	NA	NI	PB	SI	SN	TI	B	BA	CD	MN	MO	V	ZN
021	000	002	000	006	006	700	003	003	010	003	000	000	138	000	000	000	003	020	012

OIL ANALYSIS REQUEST		KEYPUNCH CODE
TO	OIL ANALYSIS LAB: New Cumberland STSGP-PE	1-3
FROM	MAJOR COMMAND: TACOM, Warren, MI 48090	4
FROM	OPERATING ACTIVITY (Include ZIP Code/APO) DODAAD: DRSTA-RGRD Mr. R. Rimpela Warren, Michigan 48090 AVN: 786-8528	5-10
EQUIPMENT MODEL/APL: Cummins VTA-903 Engine		11-14
EQUIPMENT SER. NO.		15-20
END ITEM MODEL/HULL NO.		
END ITEM SER. NO./LIC		
DATE SAMPLE TAKEN (Day, Mo., Yr.)	LOCAL TIME SAMPLE TAKEN	21-24
HOURS/MILES SINCE OVERHAUL: 400 Hour NATO Test		25-29
HOURS/MILES SINCE OIL CHANGE		30-33
REASON FOR SAMPLE: ☐ ROUTINE ☐ LAB REQUEST ☐ TEST CELL ☐ OTHER (Specify)		34
OIL ADDED SINCE LAST SAMPLE (Pts, Qts, Gals)		35-36
ACTION TAKEN: SAMPLE 13 TAKEN AT		
DISCREPANT ITEM: 326 HRS OF ENDURANCE		
HOW MALFUNCTIONED		
HOW FOUND: ☐ LAB REQUEST ☐ AIR OR GROUND CREW		
HOW TAKEN: ☐ DRAIN ☐ TUBE	SAMPLE TEMPERATURE: ☐ HOT ☐ COLD	TYPE OIL 37-38

REMARKS: Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance.

FOR LAB USE ONLY

SAMPLE RESPONSE TIME: 195/75						39-40
FE 41-43: 44	AG 44-46: 0	AL 47-49: 0	CR 50-52: 7	CU 53-55: 9	MG 56-58: 955	NI 59-61: 3
PB 62-64: 15	SI 65-67: 4	SN 68-70: 0	TI 71-73: 0	MO 74-76: 4		
LAB RECOMMENDATION						77-78
SAMPLE NO. 2155	SIGNATURE		FILE MAINT 79			DATA SEQ 80

DD FORM 1 NOV 77 2026 PREVIOUS EDITION WILL BE USED

OIL ANALYSIS REQUEST

KEYPUNCH CODE

TO — OIL ANALYSIS LAB: New Cumberland STSGP-PE (1-3)

FROM — MAJOR COMMAND: TACOM, Warren, MI 48090 (4)

FROM — OPERATING ACTIVITY (Include ZIP Code/APO) DODAAD (5-10):
DRSTA-RGRD Mr. R. Rimpela
Warren, Michigan 48090 AVN: 786-8528

EQUIPMENT MODEL/ANL (11-14): Cummins VTA-903 Engine

EQUIPMENT SER. NO. (15-20):

END ITEM MODEL/HULL NO.:

END ITEM SER. NO./EIC:

DATE SAMPLE TAKEN (Day, Mo., Yr) | LOCAL TIME SAMPLE TAKEN (21-24):

HOURS/MILES SINCE OVERHAUL (25-29): 400 Hour NATO Test

HOURS/MILES SINCE OIL CHANGE (30-33):

REASON FOR SAMPLE (34): ☐ ROUTINE ☐ LAB REQUEST ☐ TEST CELL ☐ OTHER (Specify)

OIL ADDED SINCE LAST SAMPLE (Pts, Qts, Gals) (35-36):

ACTION TAKEN: SAMPLE 14

DISCREPANT ITEM: TAKEN AT 350

HOW MALFUNCTIONED: HOURS OF ENDURANCE

HOW FOUND: ☐ LAB REQUEST ☐ AIR OR GROUND CREW

HOW TAKEN: ☐ DRAIN ☐ TUBE | SAMPLE TEMPERATURE: ☐ HOT ☐ COLD | TYPE OIL (37-38):

REMARKS: Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance. 209/75

FOR LAB USE ONLY

SAMPLE RESPONSE TIME (39-40):

FE 41-43	AG 44-46	AL 47-49	CR 50-52	CU 53-55	MG 56-58	NI 59-61
51	0	3	8	9	998	3

PB 62-64	SI 65-67	SN 68-70	TI 71-73	MO 74-76
17	5	0	0	5

LAB RECOMMENDATION (77-78): 2156

SAMPLE NO. | SIGNATURE | FILE MAINT 79 | DATA SEQ 80

DD FORM 1 NOV 77 2026 PREVIOUS EDITION WILL BE USED

OIL ANALYSIS REQUEST		KEYPUNCH CODE
TO	OIL ANALYSIS LAB New Cumberland STSGP-PE	1-3
	MAJOR COMMAND TACOM, Warren, MI 48090	4
FROM	OPERATING ACTIVITY (Include ZIP Code/APO) DODAAD DRSTA-RGRD Mr. R. Rimpela Warren, Michigan 48090 AVN: 786-8528	5-10
EQUIPMENT MODEL/ARR Cummins VTA-903 Engine		11-14
EQUIPMENT SER. NO.		15-20
END ITEM MODEL/HULL NO.		
END ITEM SER. NO./EIC		
DATE SAMPLE TAKEN (Day, Mo., Yr)	LOCAL TIME SAMPLE TAKEN	21-24
HOURS/MILES SINCE OVERHAUL 400 Hour NATO Test		25-29
HOURS/MILES SINCE OIL CHANGE		30-33
REASON FOR SAMPLE ☐ ROUTINE ☐ LAB REQUEST ☐ TEST CELL ☐ OTHER (Specify)		34
OIL ADDED SINCE LAST SAMPLE (Pts, Qts, Gals)		35-36
ACTION TAKEN SAMPLE 15		
DISCREPANT ITEM TAKEN AT 375		
HOW MALFUNCTIONED HOURS OF ENDORANCE		
HOW FOUND ☐ LAB REQUEST ☐ AIR OR GROUND CREW		
HOW TAKEN ☐ DRAIN ☐ TUBE	SAMPLE TEMPERATURE ☐ HOT ☐ COLD / TYPE OIL	37-38

REMARKS Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance.

FOR LAB USE ONLY

SAMPLE RESPONSE TIME 223/74						39-40
FE 41-43	AG 44-46	AL 47-49	CR 50-52	CU 53-55	MG 56-58	NI 59-61
46	0	0	9	11	188	2
PB 62-64	SI 65-67	SN 68-70	TI 71-73	MO 74-76		
18	4	19	0	2		

LAB RECOMMENDATION [illegible] 77-78

SAMPLE NO.	SIGNATURE	FILE MAINT	DATA SEQ
SP 22			80

DD FORM 2026 NOV 77 PREVIOUS EDITION WILL BE USED

OIL ANALYSIS REQUEST		KEYPUNCH CODE
TO	OIL ANALYSIS LAB: New Cumberland STSGP-PE	1-3
FROM	MAJOR COMMAND: TACOM, Warren, MI 48090	4
FROM	OPERATING ACTIVITY (Include ZIP Code/AP(s) DODAAD): DRSTA-RGRD Mr. R. Rimpela Warren, Michigan 48090 AVN: 786-8528	5-10
EQUIPMENT MODEL/ARL: Cummins VTA-903 Engine		11-14
EQUIPMENT SER. NO.		15-20
END ITEM MODEL/HULL NO.		
END ITEM SER. NO./EIC		
DATE SAMPLE TAKEN (Day, Mo., Yr)	LOCAL TIME SAMPLE TAKEN	21-24
HOURS/MILES SINCE OVERHAUL: 400 Hour NATO Test		25-29
HOURS/MILES SINCE OIL CHANGE		30-33
REASON FOR SAMPLE: ☐ ROUTINE ☐ LAB REQUEST ☐ TEST CELL ☐ OTHER (Specify)		34
OIL ADDED SINCE LAST SAMPLE (Pts, Qts, Gals)		35-36
ACTION TAKEN: SAMPLE 16 TAKEN AT 400 HOURS OF ENDURANCE		
DISCREPANT ITEM		
HOW MALFUNCTIONED		
HOW FOUND: ☐ LAB REQUEST ☐ AIR OR GROUND CREW		
HOW TAKEN: ☐ DRAIN ☐ TUBE	SAMPLE TEMPERATURE: ☐ HOT ☐ COLD / TYPE OIL	37-38

REMARKS: Oil sample spectrographic analysis is required for NATO 400 hour tests. Samples will be taken every 25 hours. Complete oil change after every 100 hours of endurance.

FOR LAB USE ONLY

SAMPLE RESPONSE TIME: 22/7/74						39-40
FE 41-43: 57	AG 44-46: 0	AL 47-49: 0	CR 50-52: 10	CU 53-55: 13	MG 56-58: 823	NI 59-61: 3
PB 62-64: 23	SI 65-67: 4	SN 68-70: 19	TI 71-73: 0	MO 74-76: 2		
LAB RECOMMENDATION: Need to check Engine oil						77-78
SAMPLE NO.: SP 23	SIGNATURE	FILE MAINT				DATA SEQ 80

DD FORM 1 NOV 77 2026 PREVIOUS EDITION WILL BE USED

UTJ8Z FORMAT TO UPDATE SOAPIN FILE

SAMPLE 13 TAKEN AT 326 HRS

COMP TYPE	COMP SER	SAMPLE NUMBER	DATE	DAYS IN TRANSIT	OSOH	OSOC	REASON FOR SAMPLE
DENG		2155	3231	07	0000	326	400HRNATO

FE	AG	AL	BE	CR	CU	MG	NA	NI	PB	SI	SN	TI	B	BA	CD	MN	MO	V	ZN
044	000	000	000	007	009	955	000	003	015	004	000	000	168	000	000	000	004	018	121

UTJ8Z4 FORMAT TO UPDATE SOAPIN FILE

SAMPLE 14 TAKEN AT 350 HRS

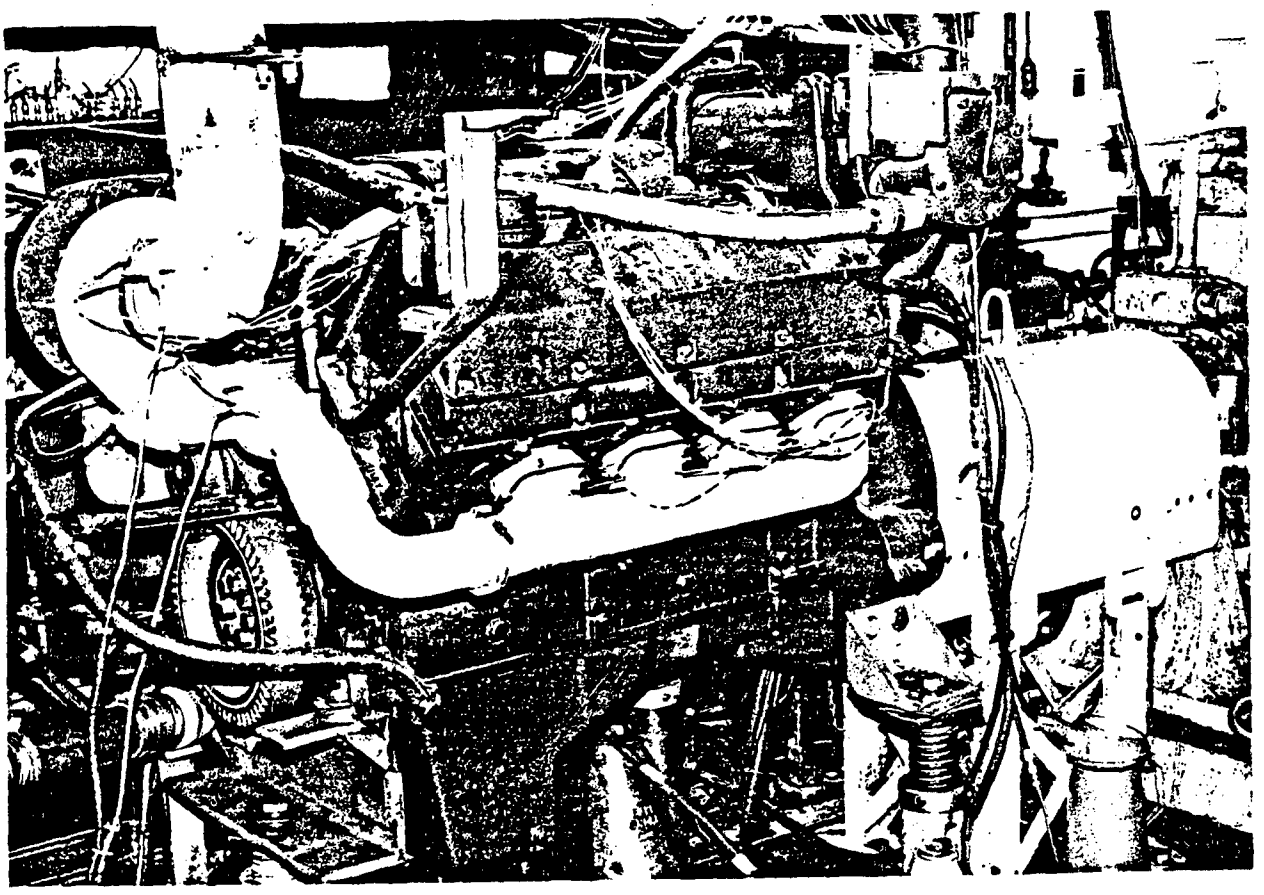
COMP TYPE	COMP SER	SAMPLE NUMBER	DATE	DAYS IN TRANSIT	OSOH	OSOC	REASON FOR SAMPLE
DENG		2156	3231	07	0000	350	400HRNATO

FE	AG	AL	BE	CR	CU	MG	NA	NI	PB	SI	SN	TI	B	BA	CD	MN	MO	V	ZN
051	000	003	000	008	009	998	000	003	017	005	000	000	148	000	000	002	005	017	172

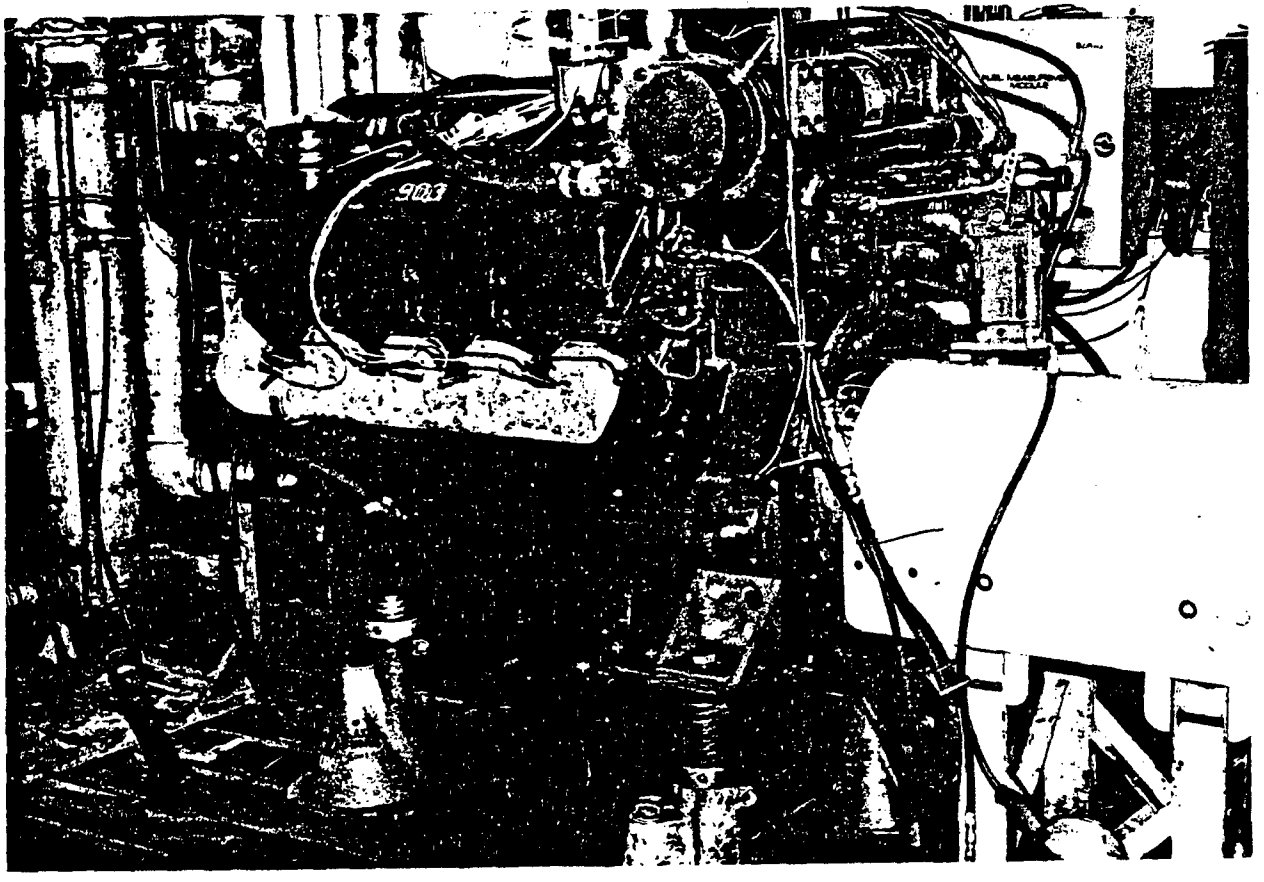
SAMPLE 15 TAKEN AT 375 HRS

SAMPLE 16 TAKEN AT 400 HRS

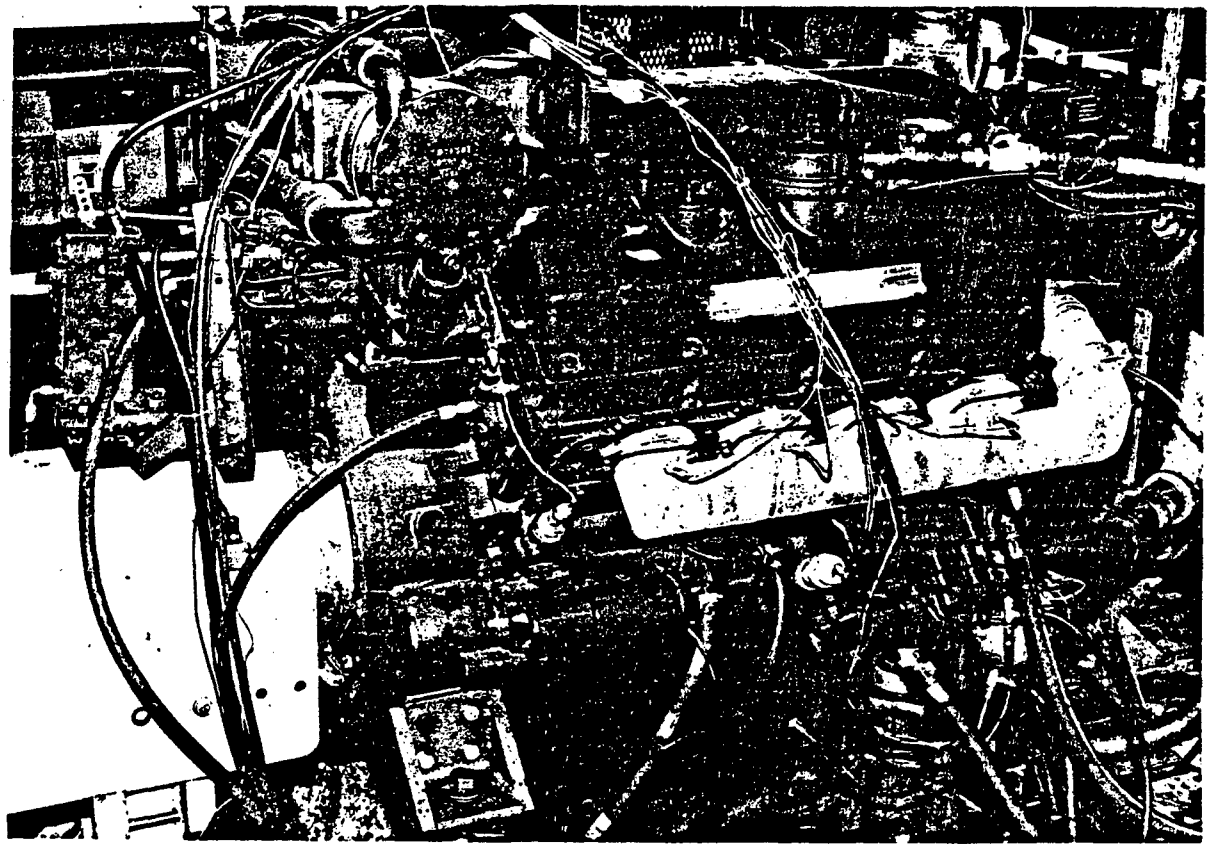
APPENDIX F - Photographs



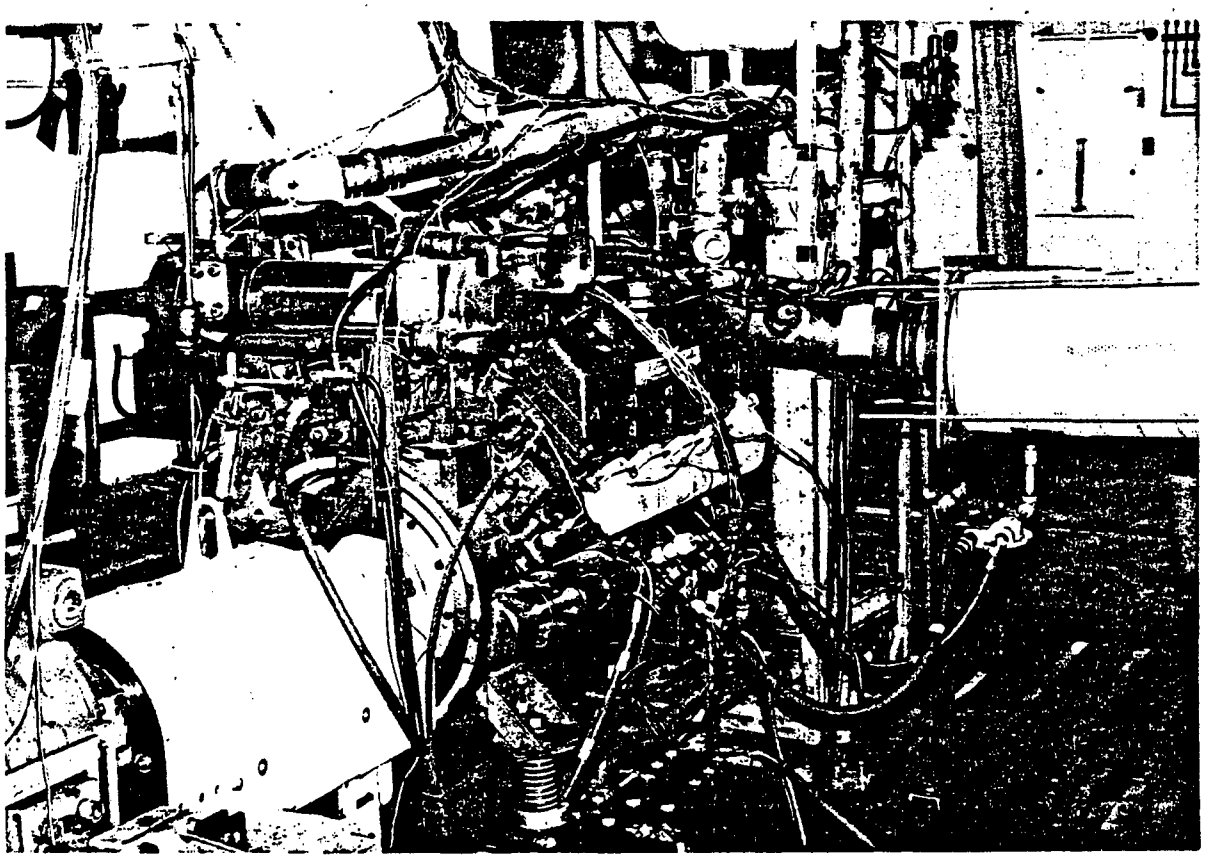
ENGINE TEST SET-UP, LEFT FRONT



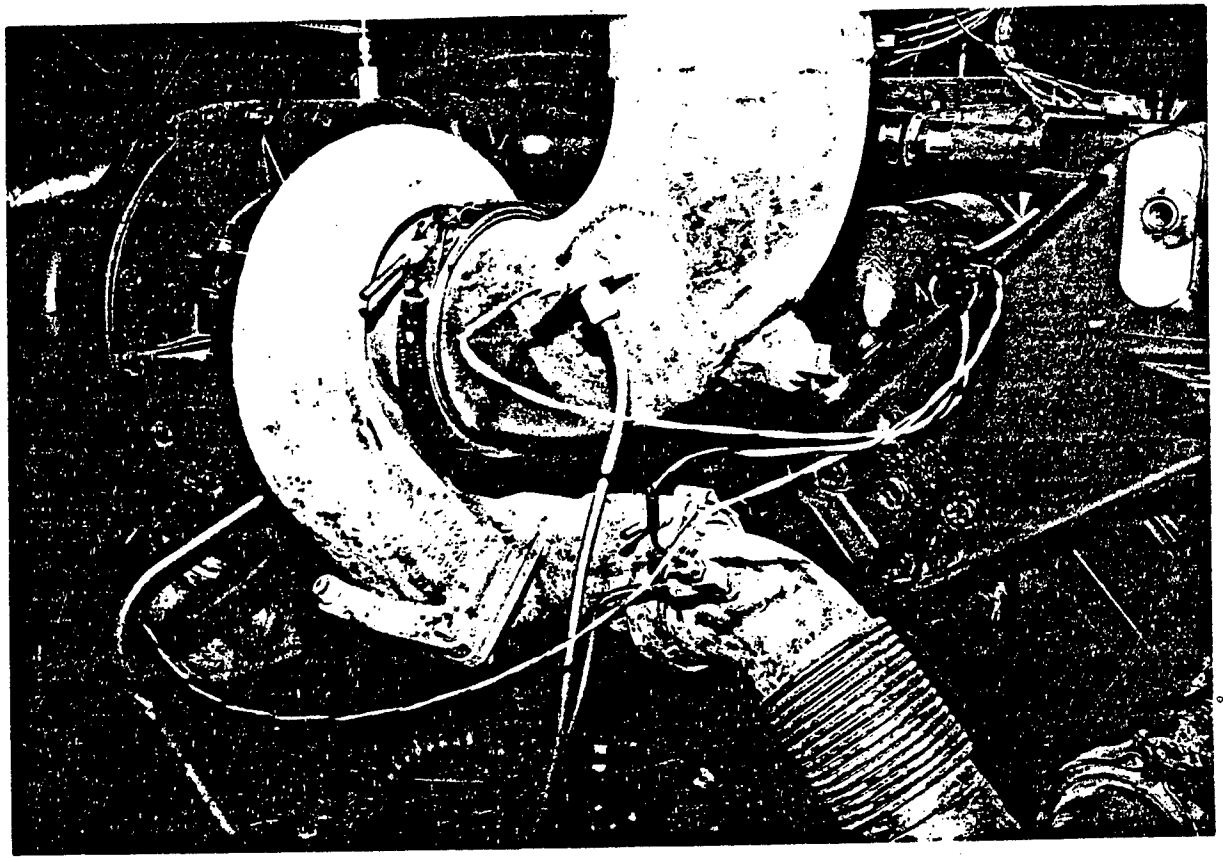
ENGINE TEST SET-UP, LEFT REAR



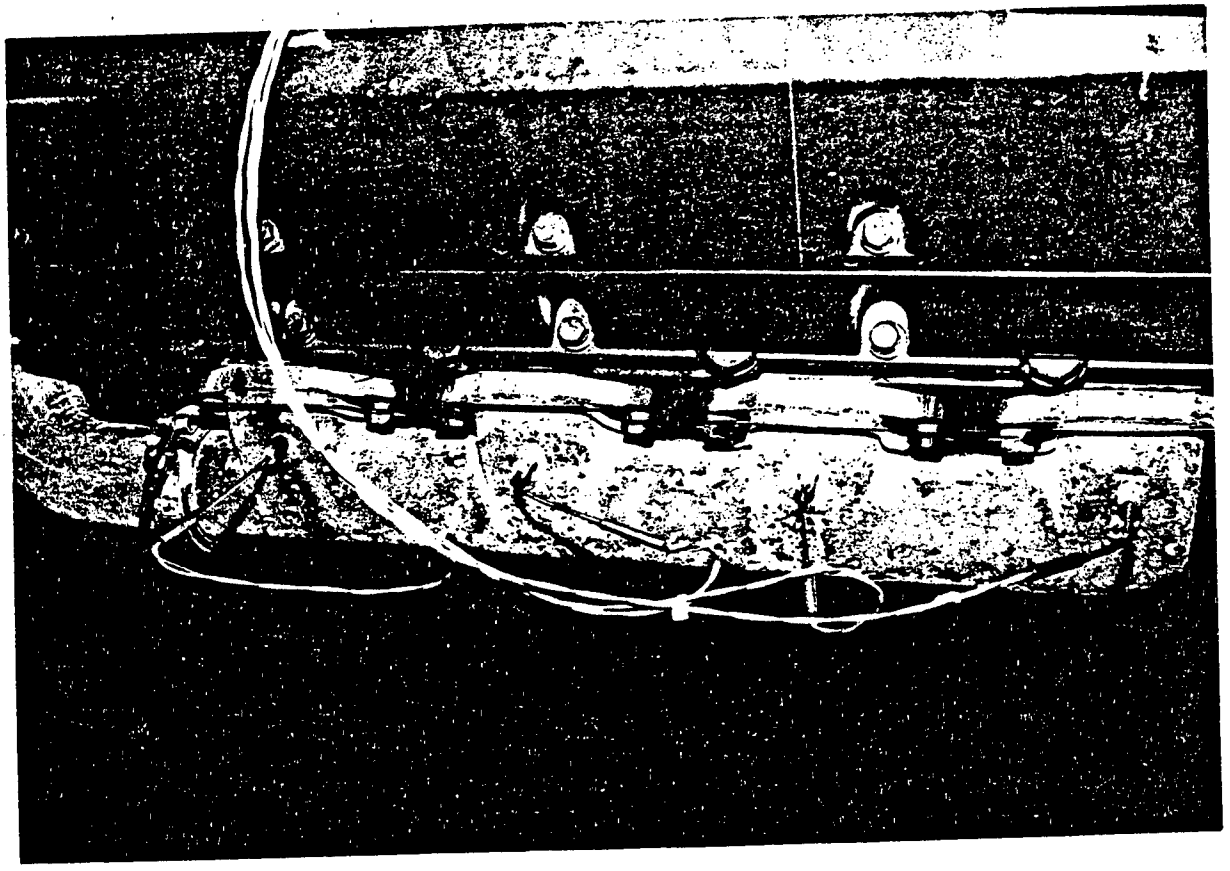
ENGINE TEST SET-UP, RIGHT SIDE



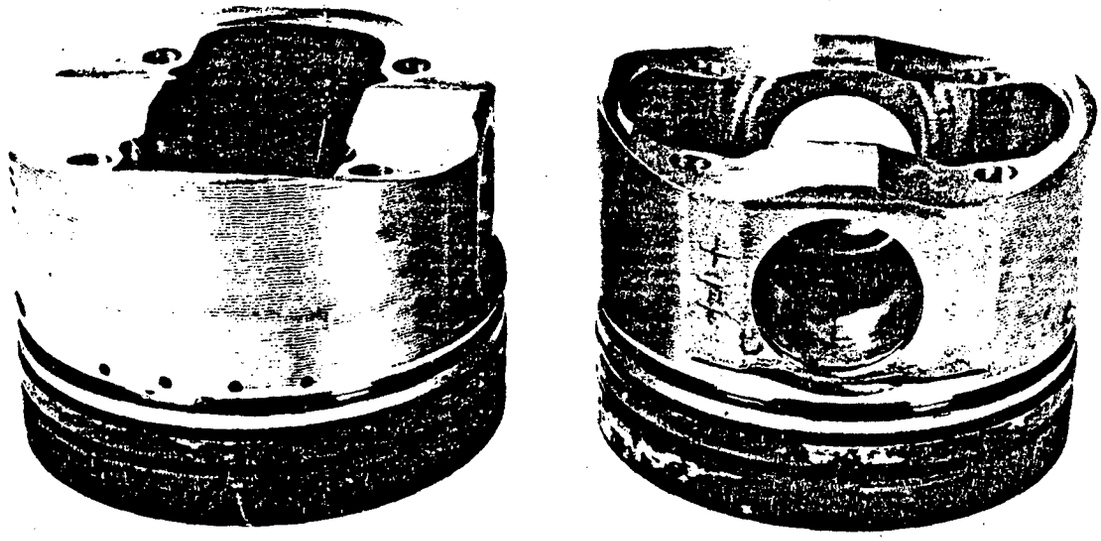
ENGINE TEST SET-UP, RIGHT REAR



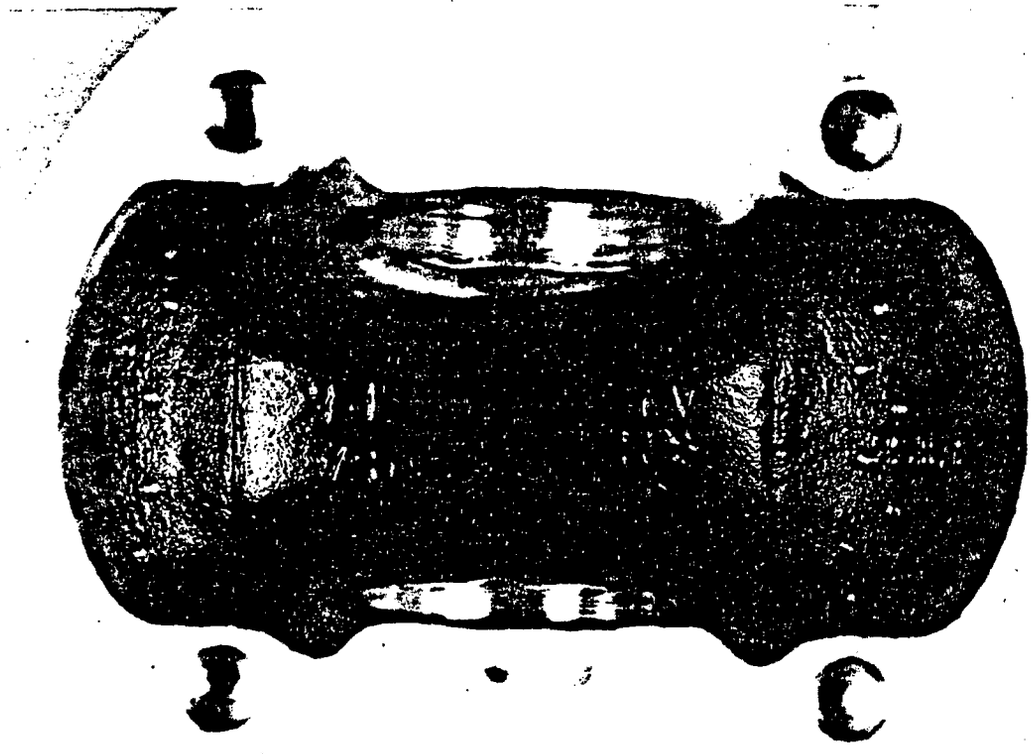
ENGINE TEST SET-UP, TURBOCHARGER



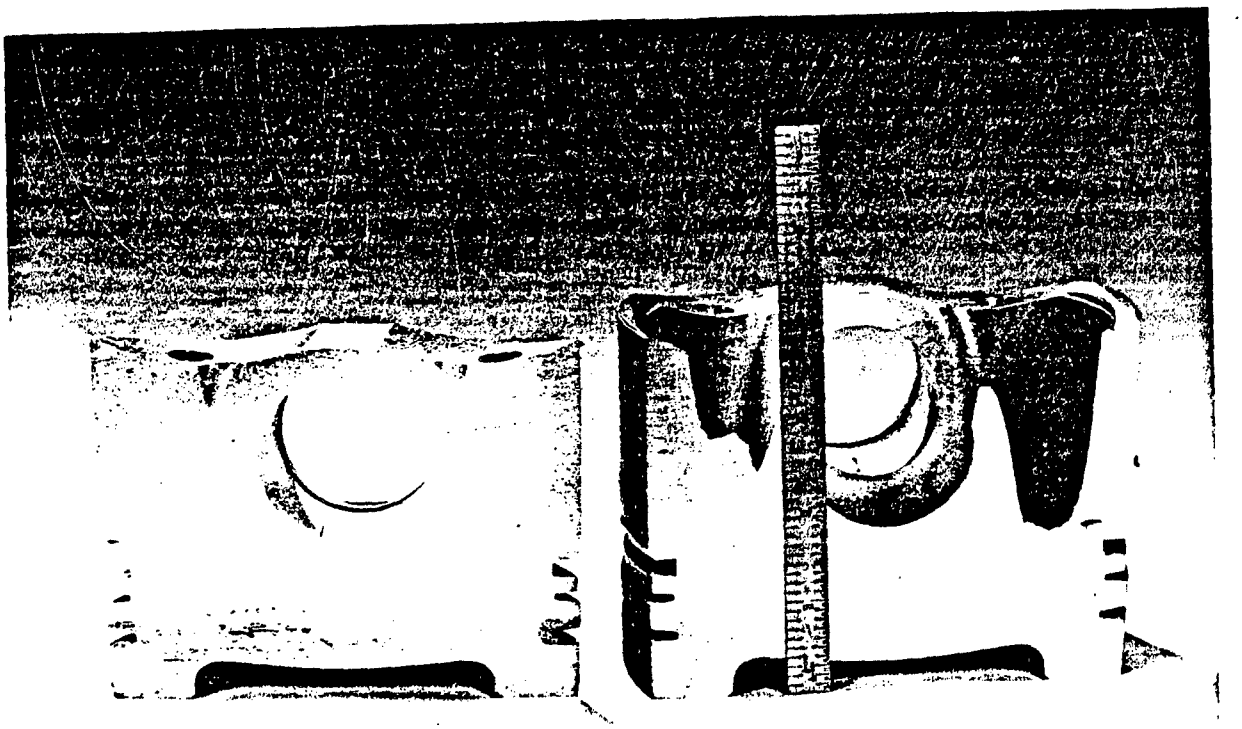
ENGINE TEST SET-UP, LEFT SIDE

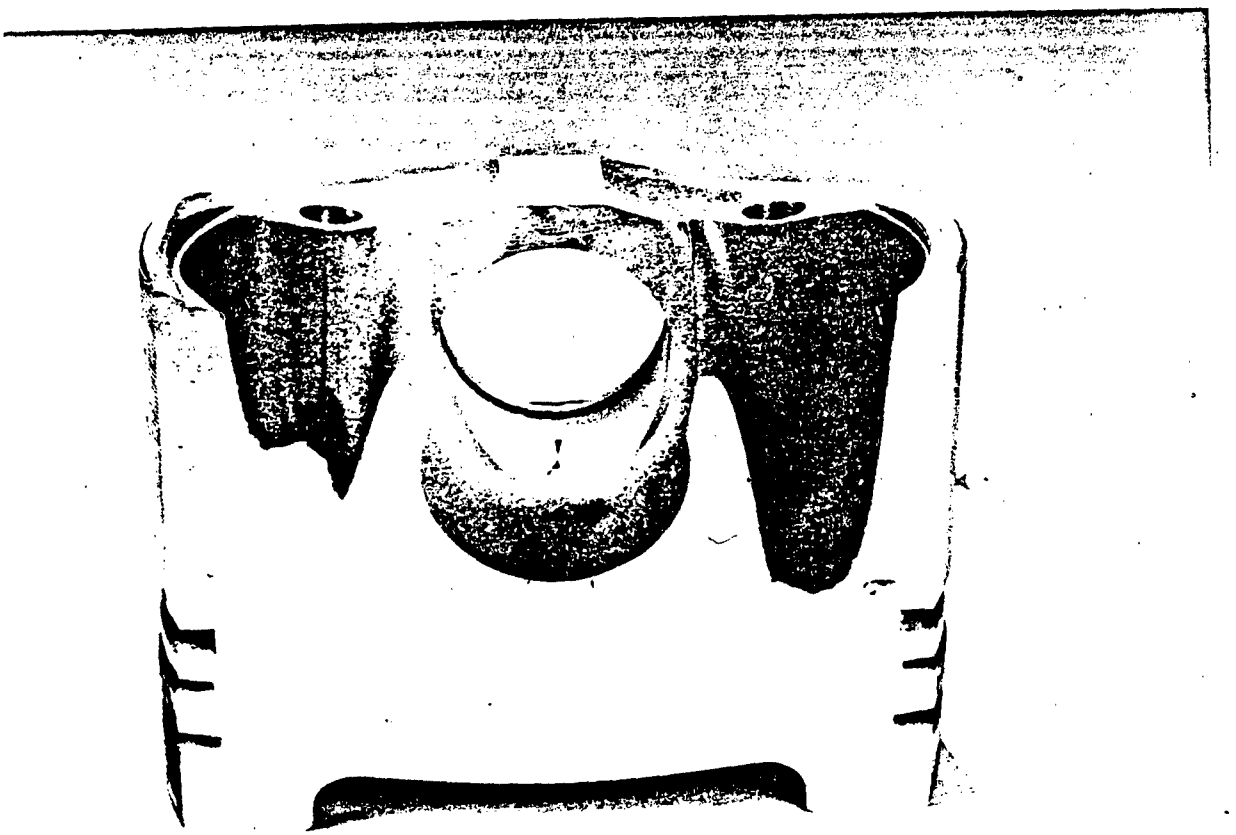


PISTONS - TYPICAL CLEAN APPEARANCE

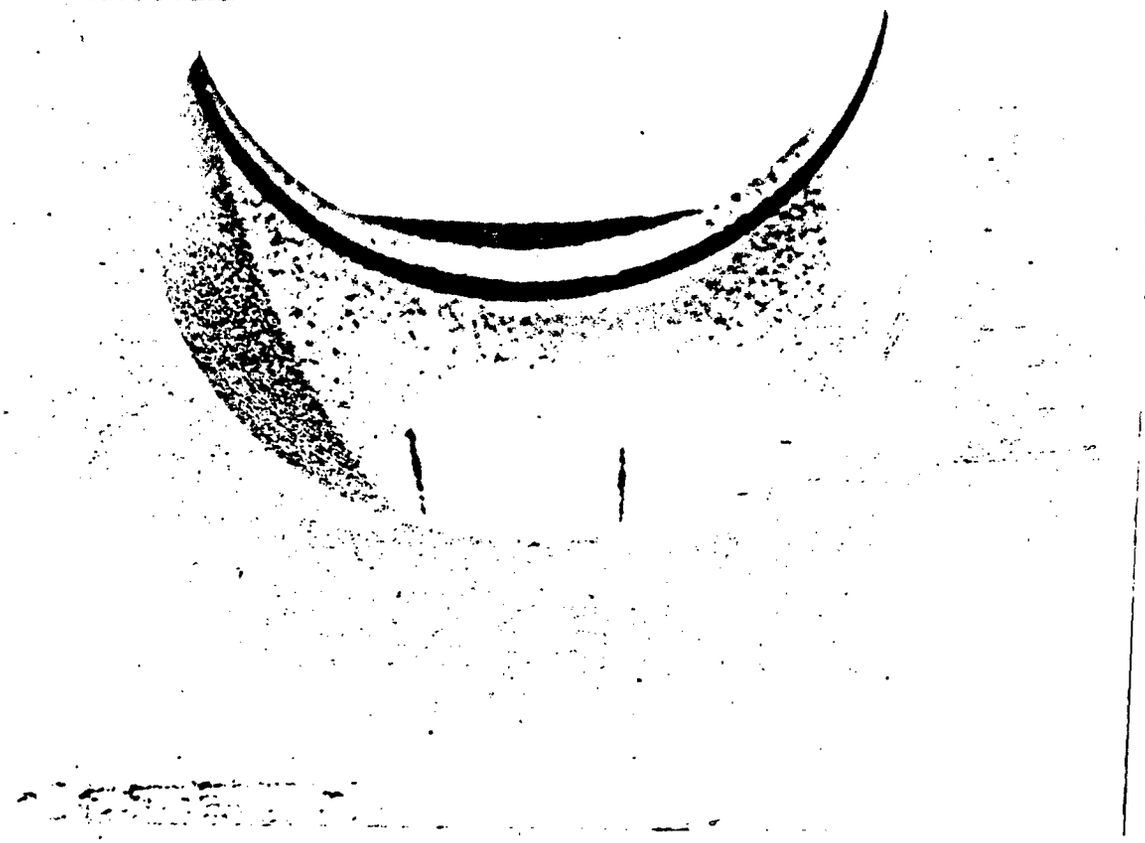


PISTON - TYPICAL BOTTOM SIDE OF PISTON HEAD

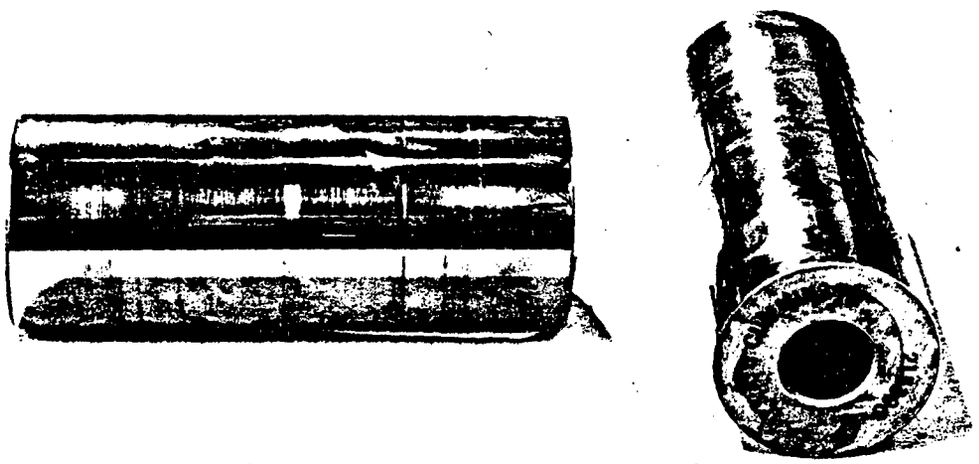




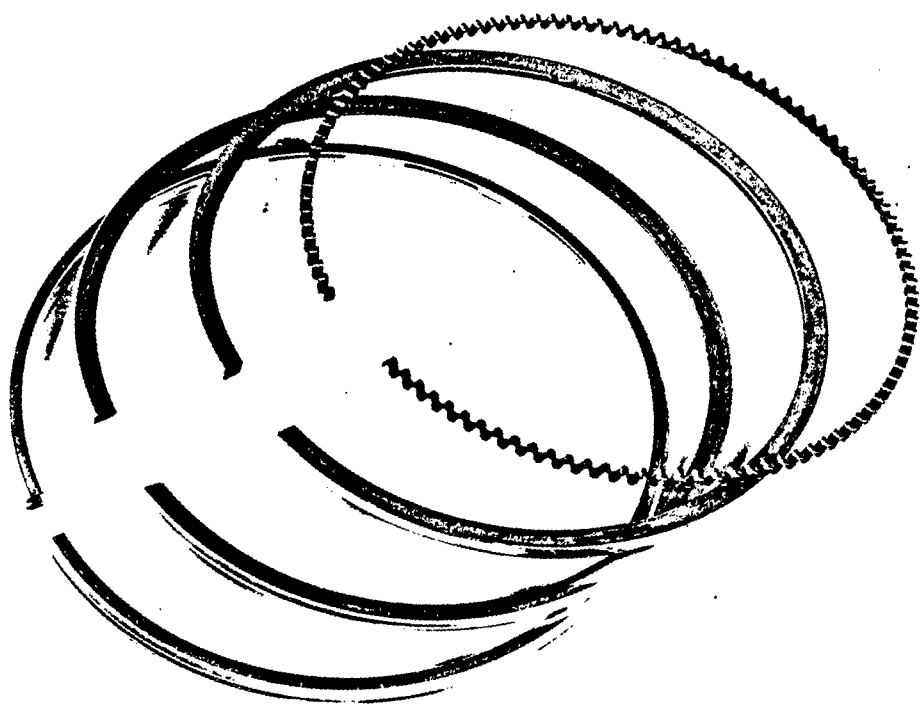
PISTON - SECTIONED TO DISPLAY PIN BORE CRACKS (WITH DYEPENETRANT)



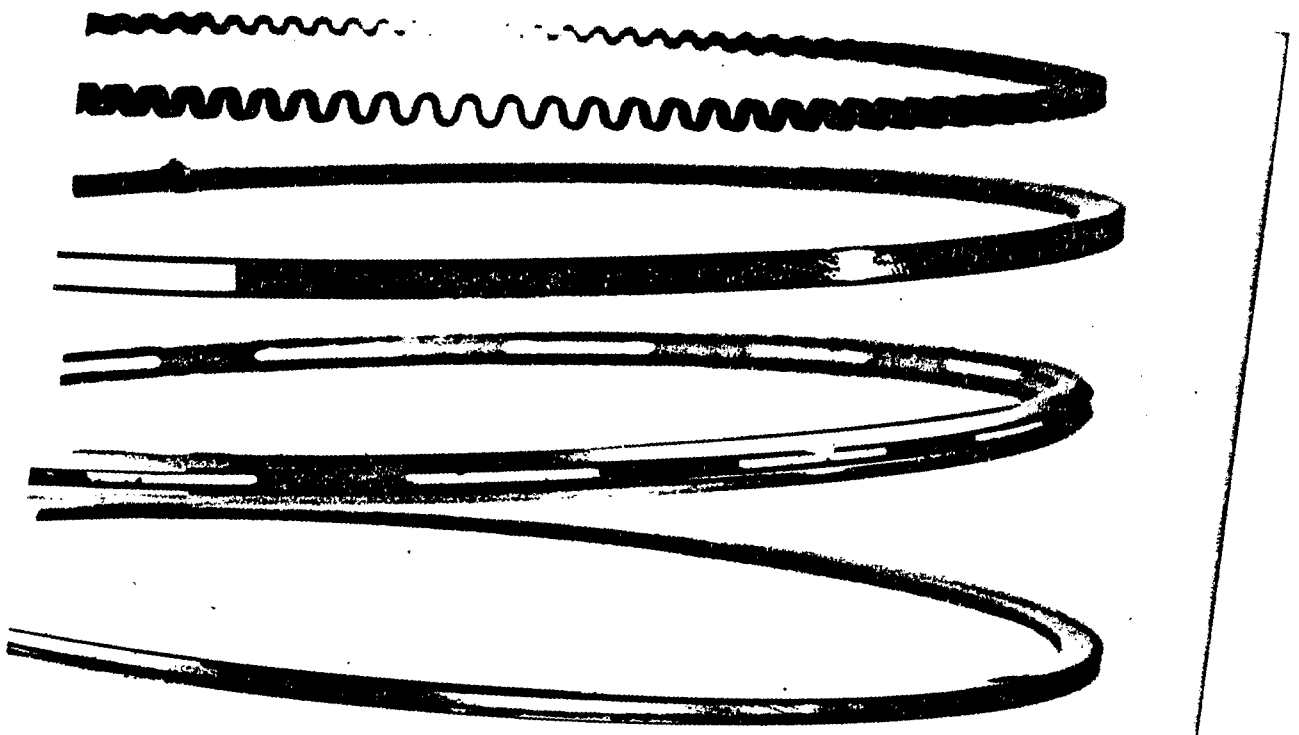
PISTON - SECTIONED TO DISPLAY PIN BORE CRACKS



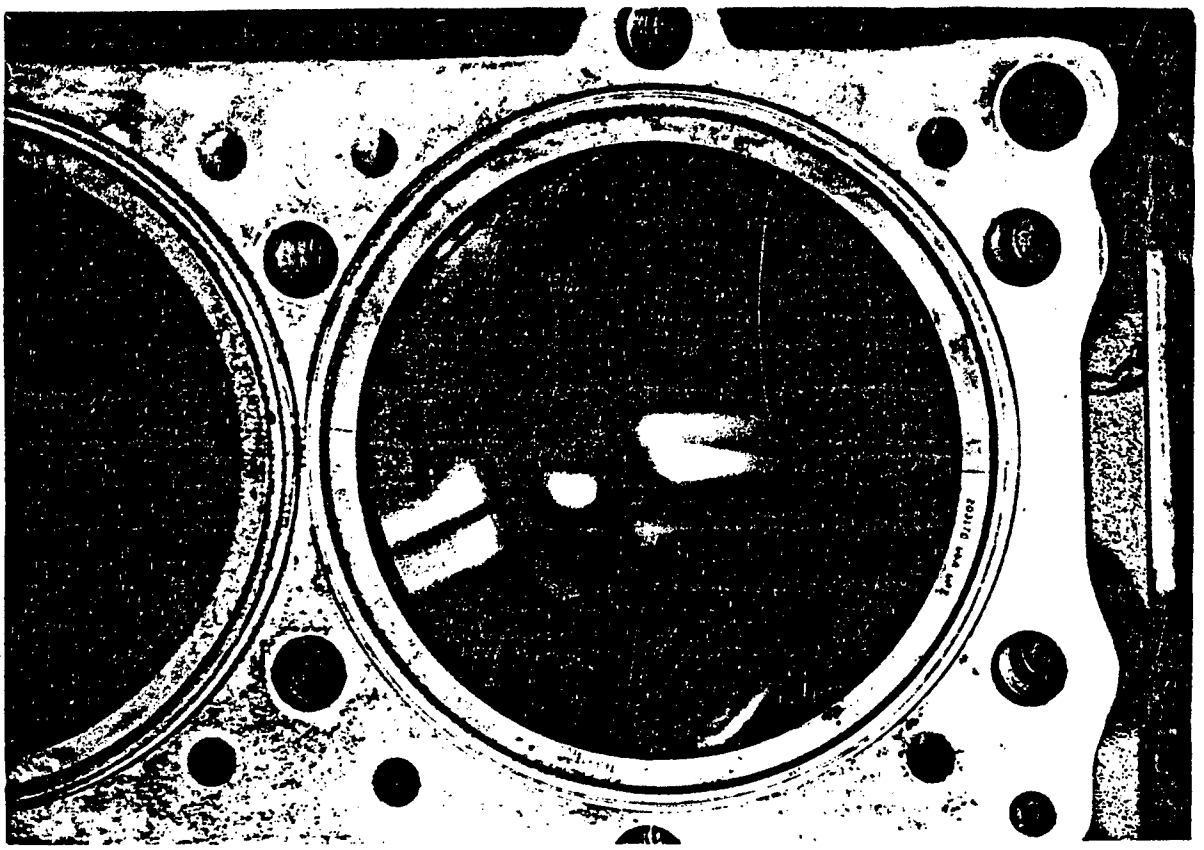
PISTON PIN - TYPICAL APPEARANCE - NO VISIBLE WEAR



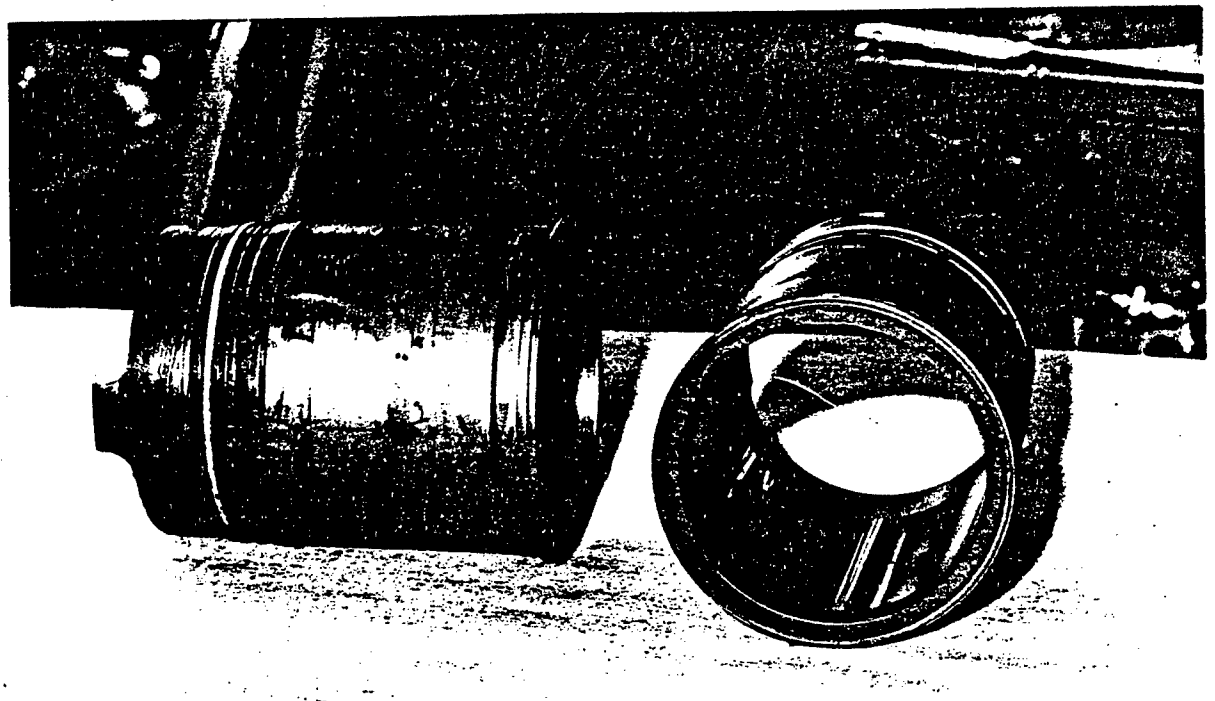
TYPICAL PISTON RINGS - NO BREAKAGE



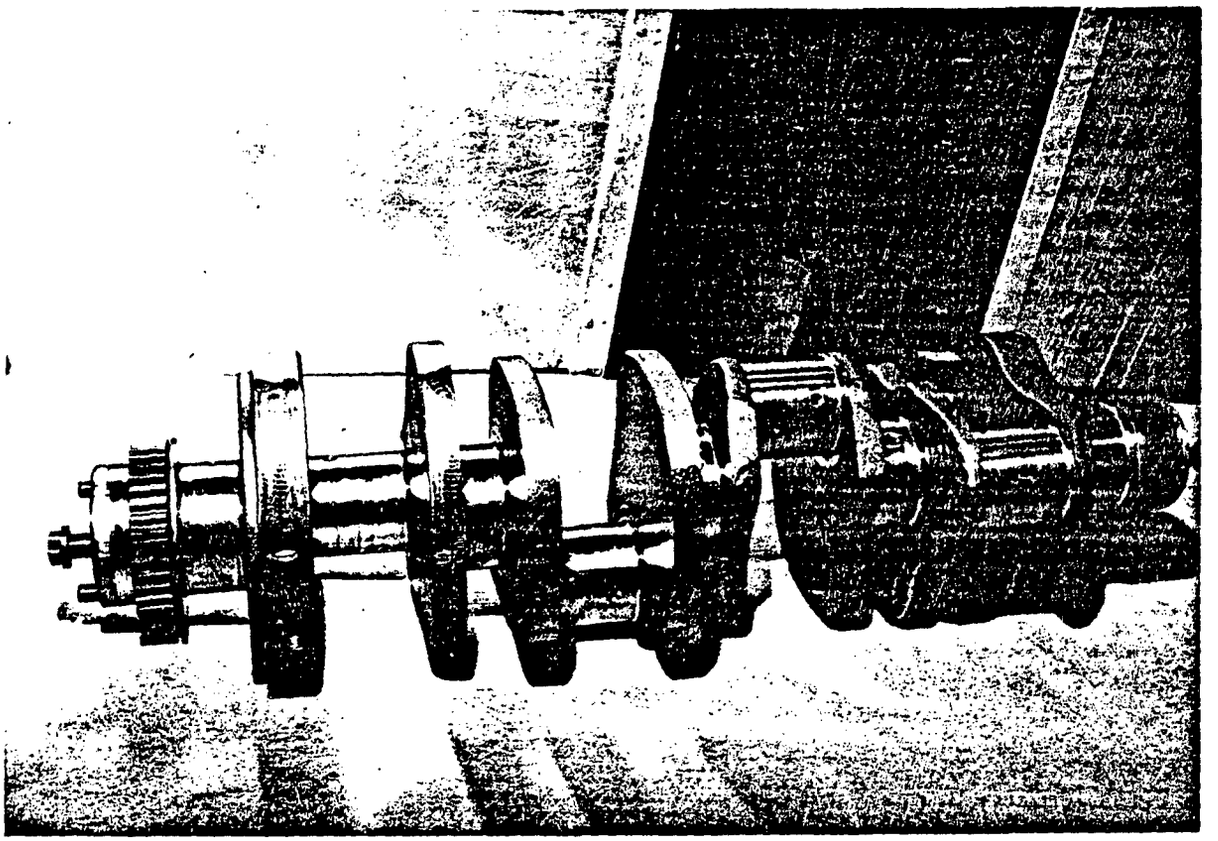
TYPICAL PISTON RINGS - NO SIGNS OF STRESS



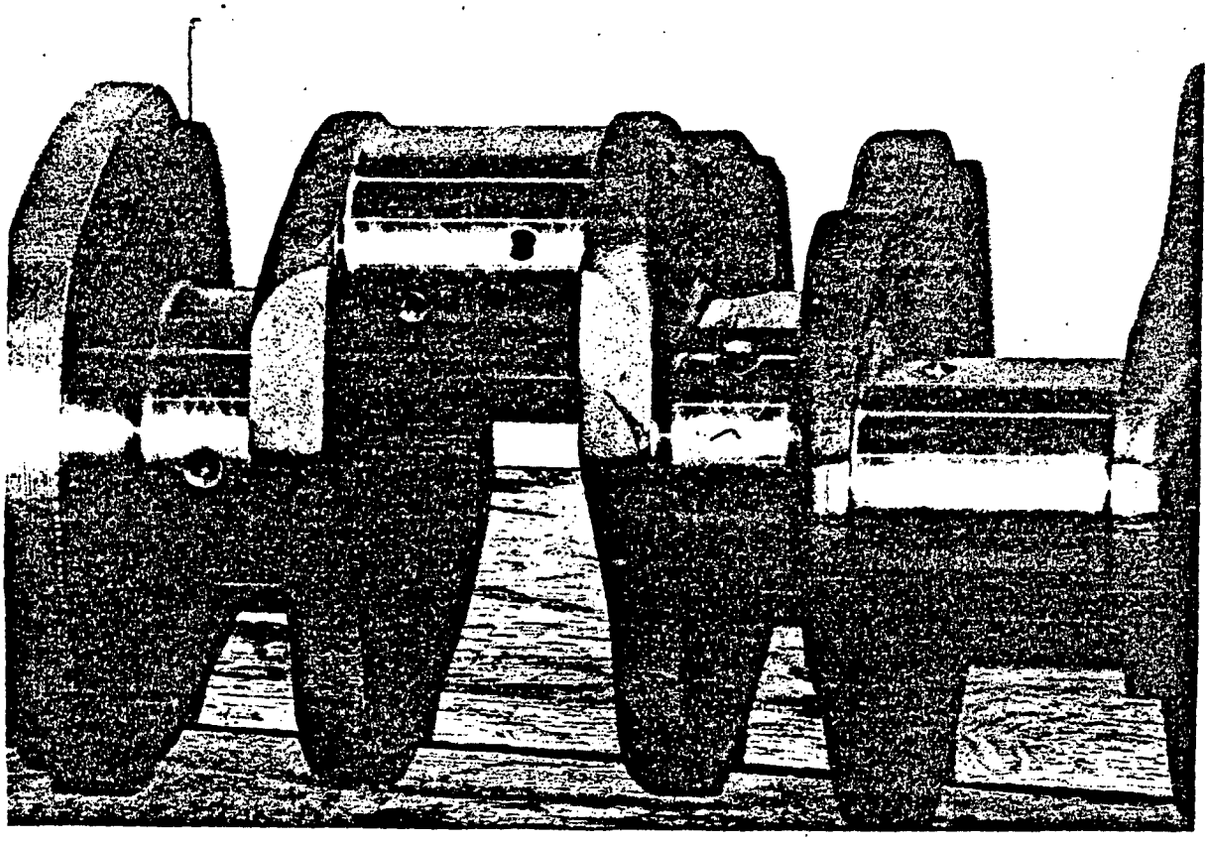
CYLINDER LINERS - EXCELLENT CONDITION



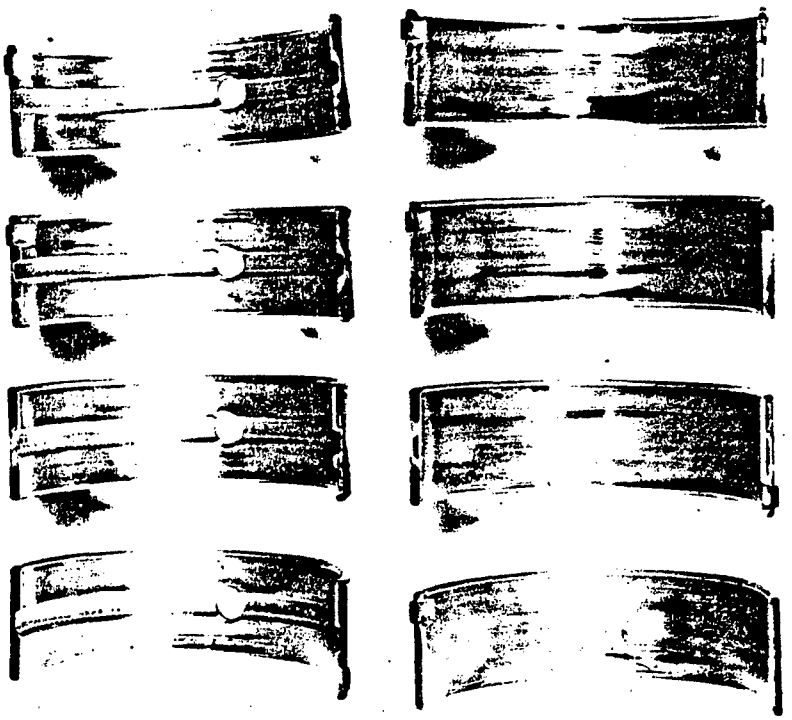
CYLINDER LINERS (REMOVED) - EXCELLENT CONDITION



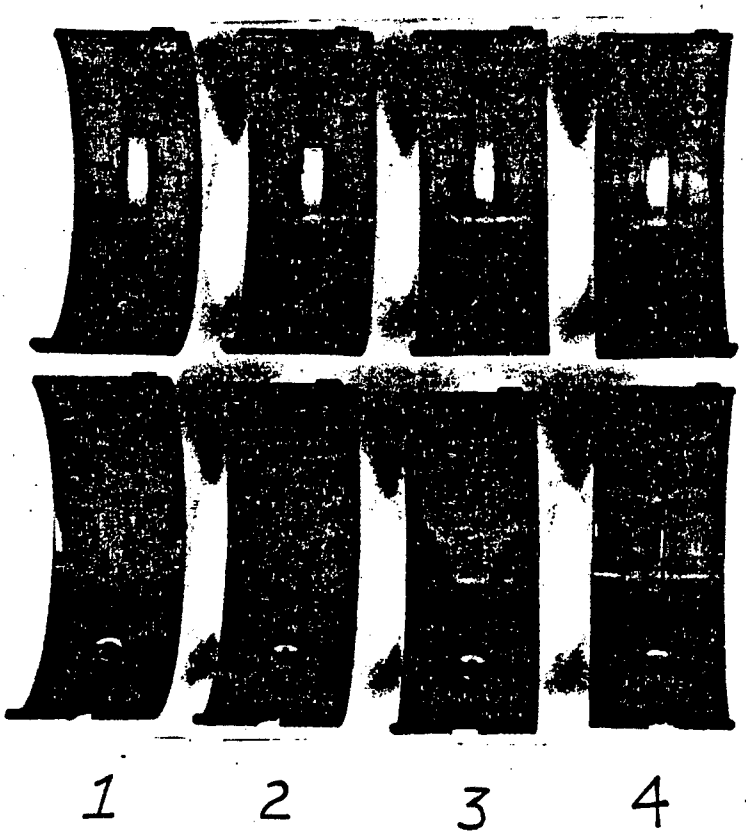
CRANKSHAFT - EXCELLENT CONDITION



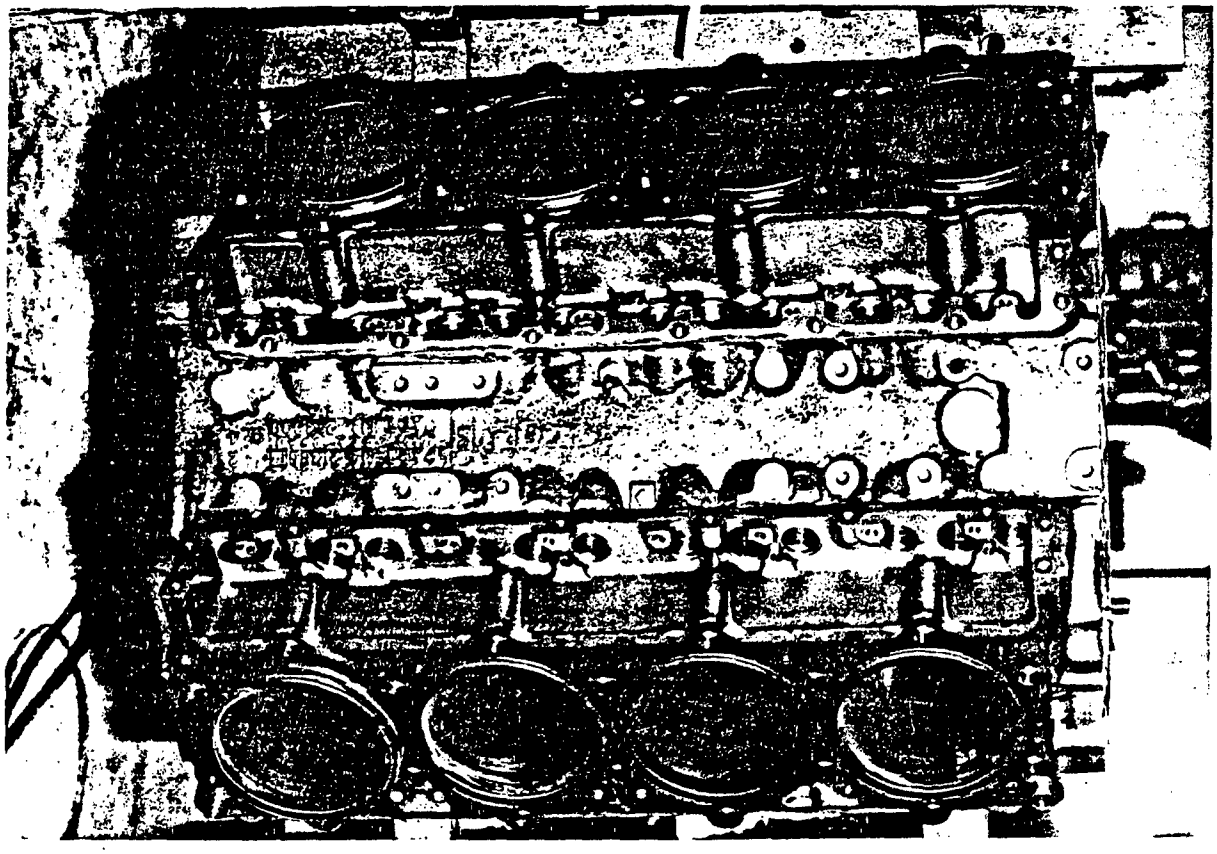
CRANKSHAFT -MAIN AND ROD JOURNALS
EXCELLENT CONDITION



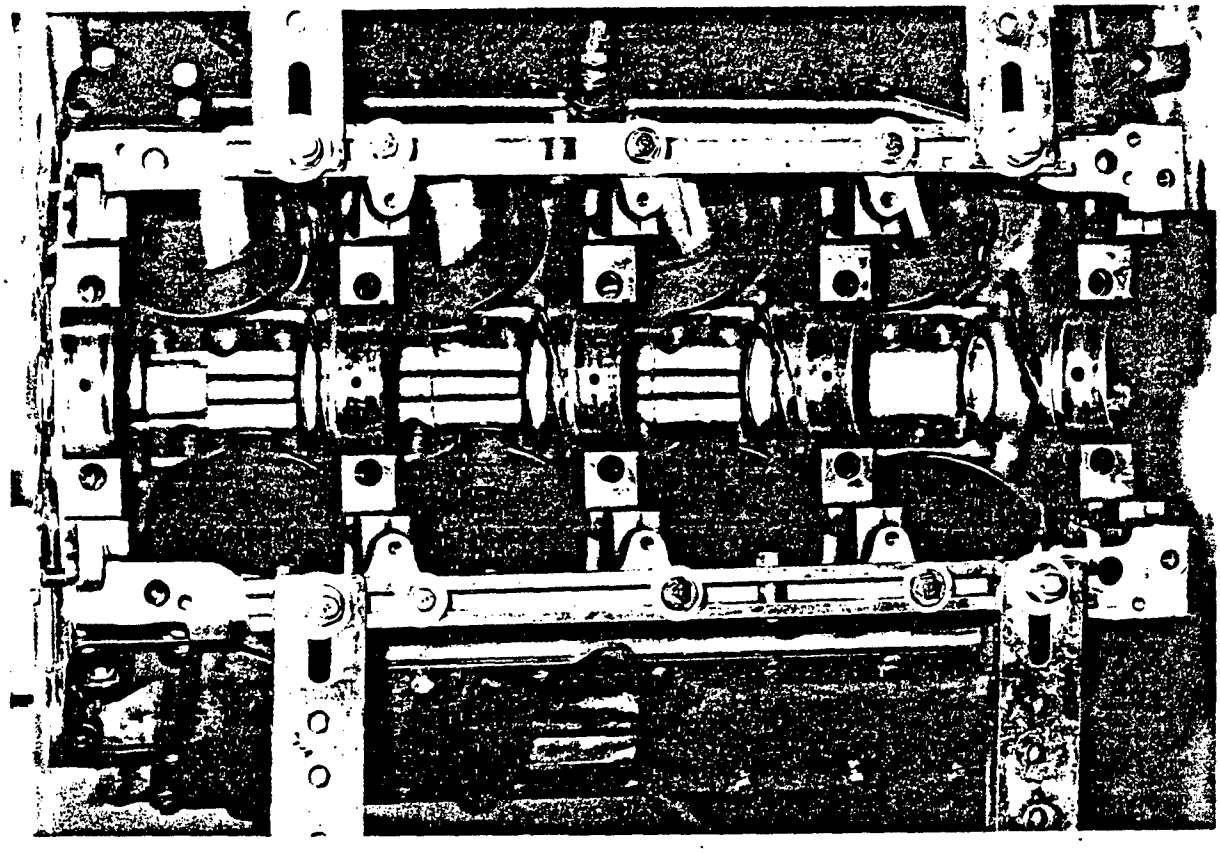
MAIN BEARINGS - NO OVERLAY BREAKTHROUGH



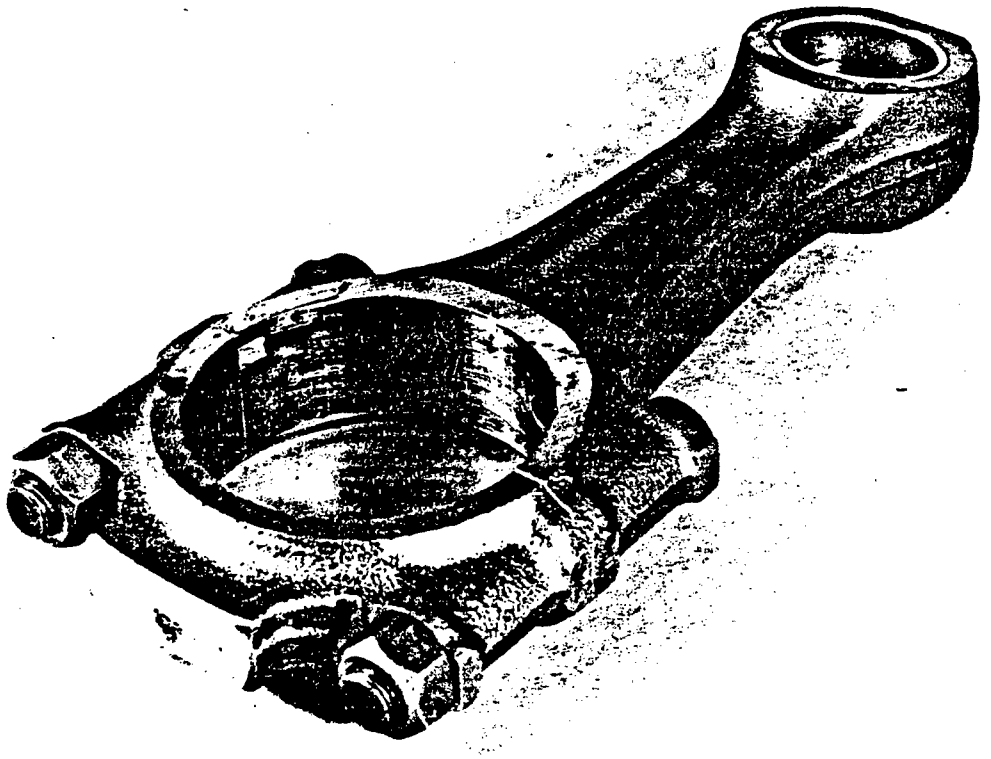
ROD BEARINGS - NO OVERLAY BREAKTHROUGH



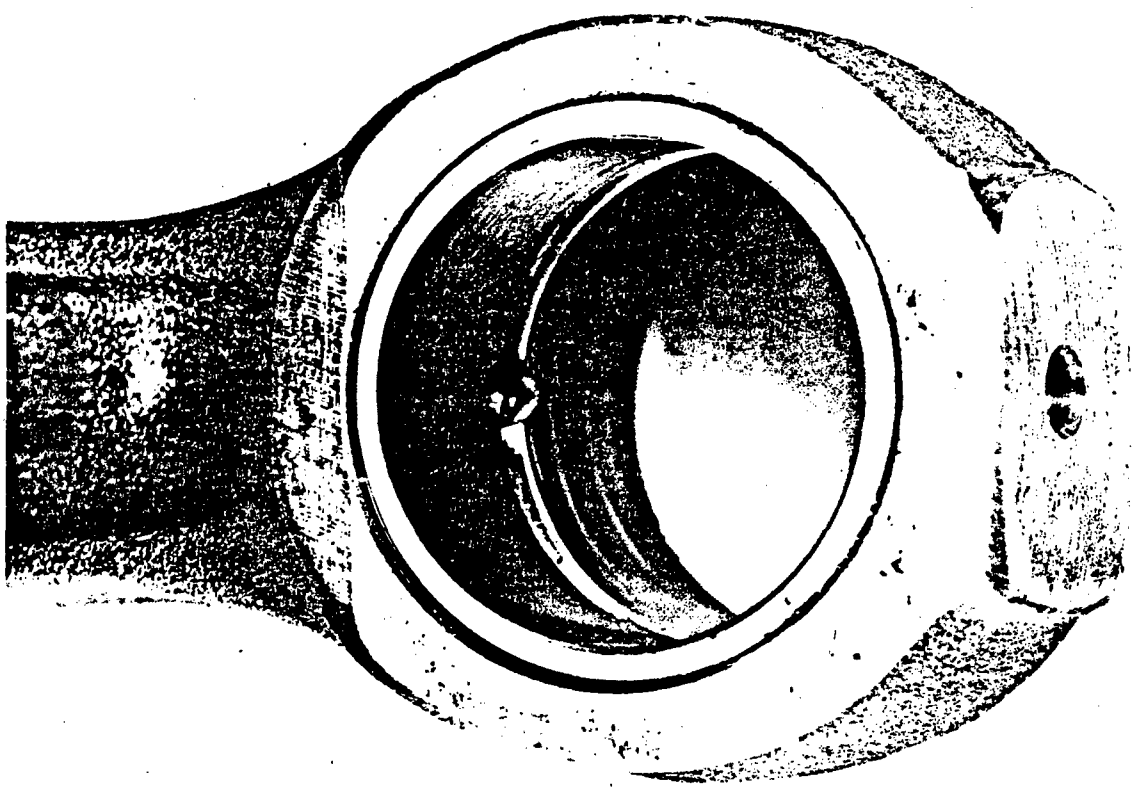
ENGINE BLOCK - TOP VIEW WITH LINERS -
EXECELLENT CONDITION



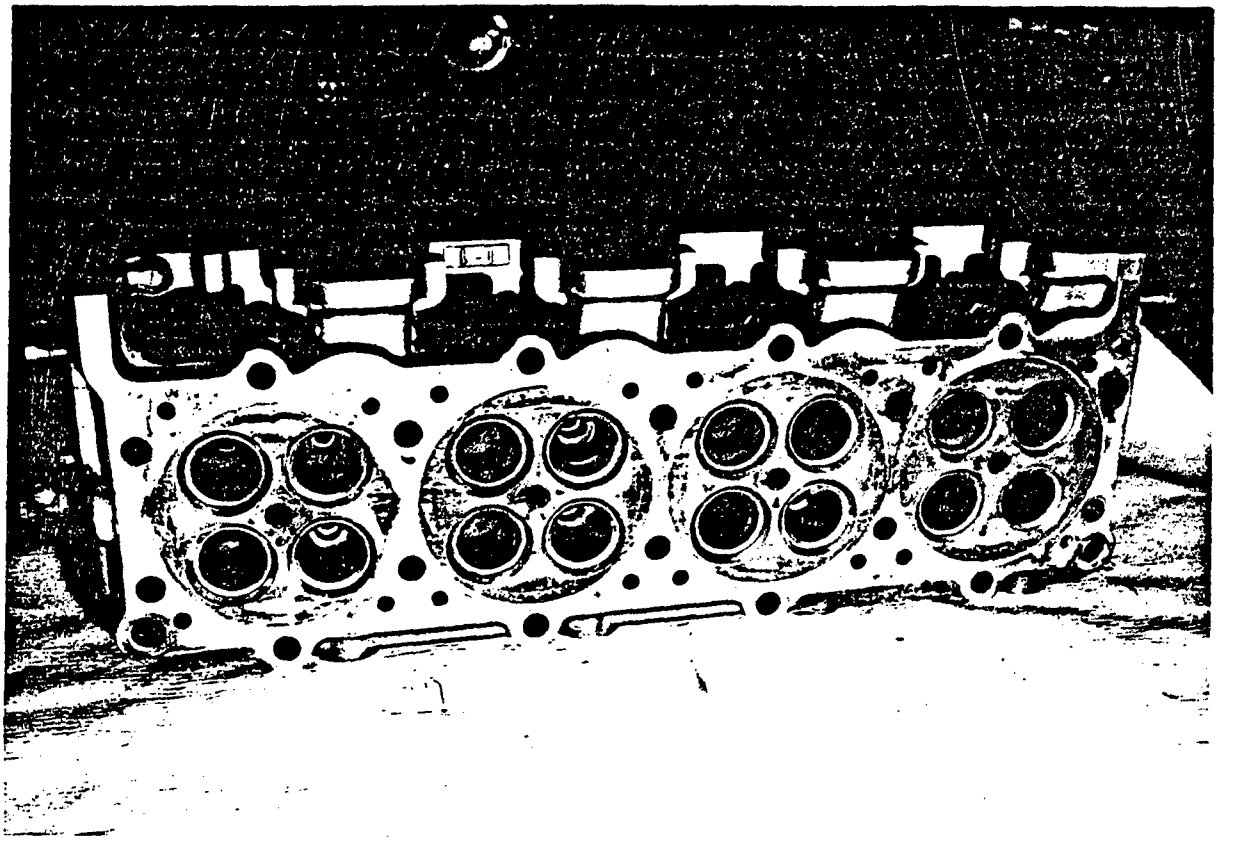
ENGINE BLOCK - BOTTOM VIEW WITH LINERS -
EXCELLENT CONDITIONS

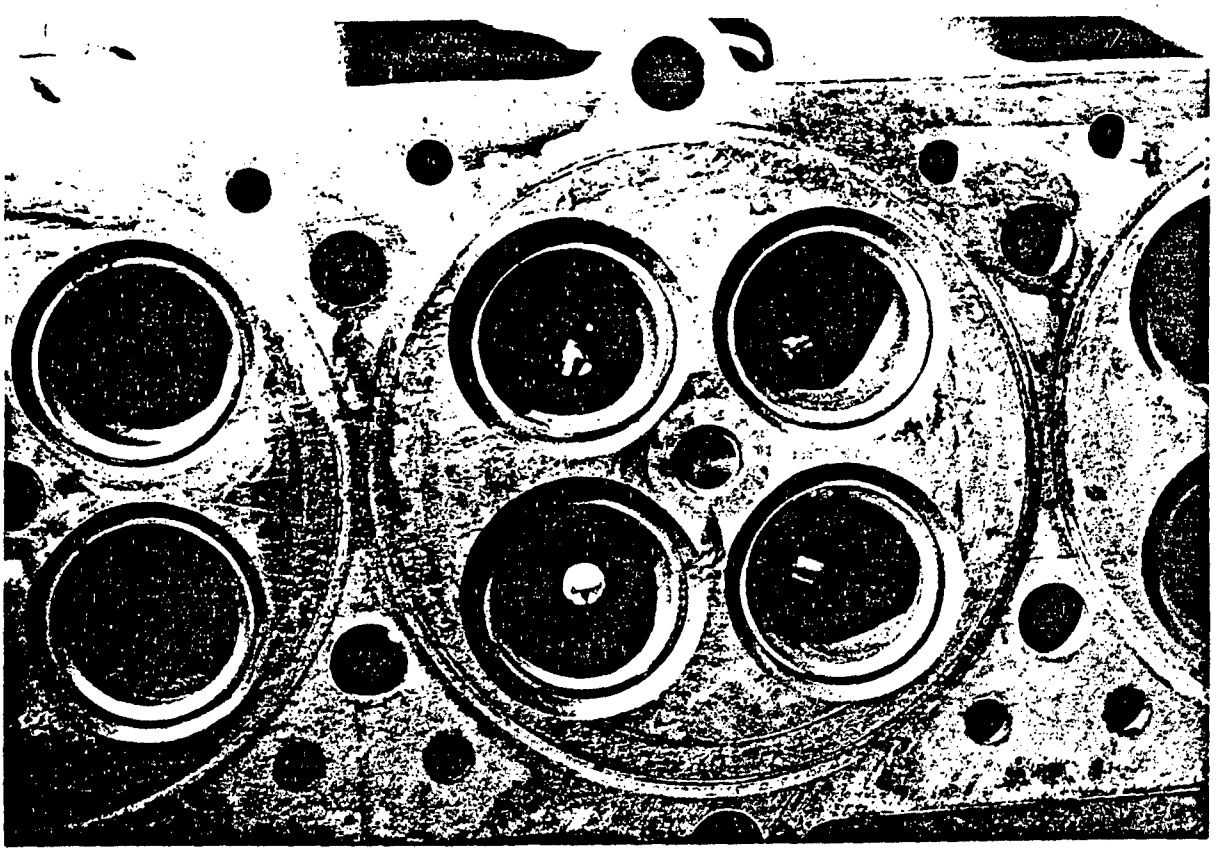


CONNECTING ROD

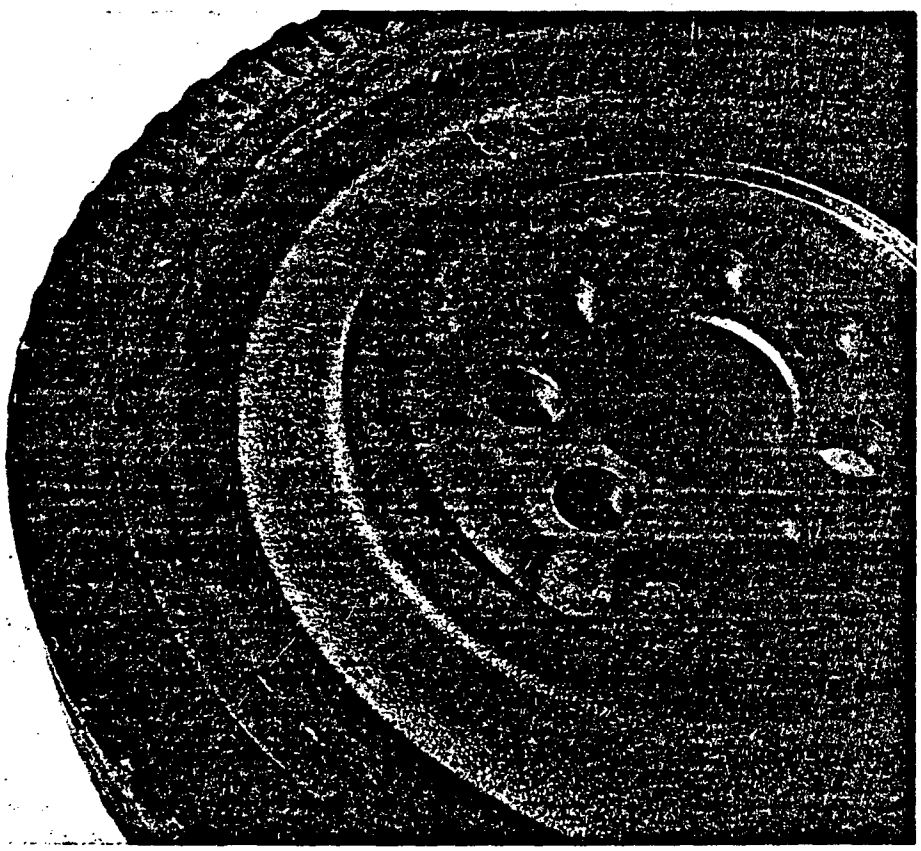


CONNECTING ROD BUSHING - TYPICAL GOOD APPEARANCE

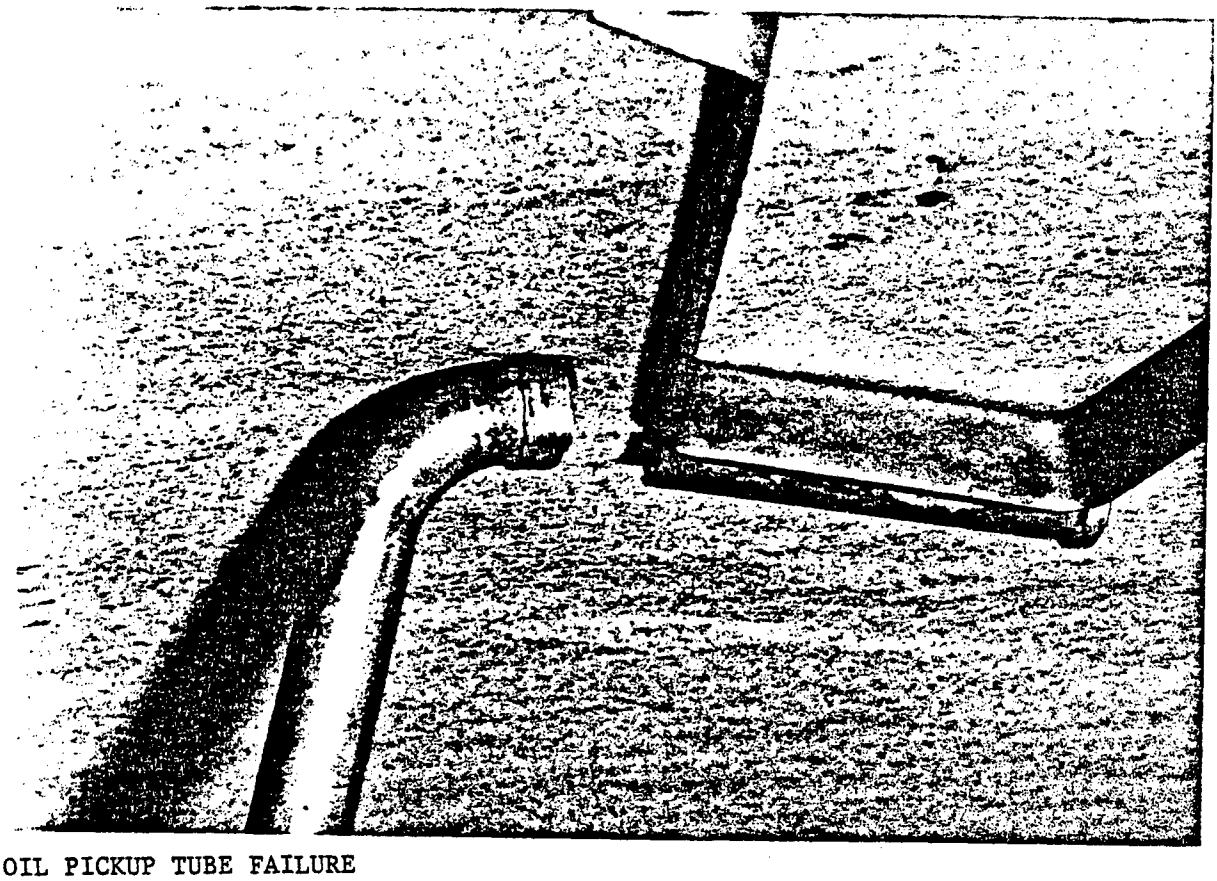




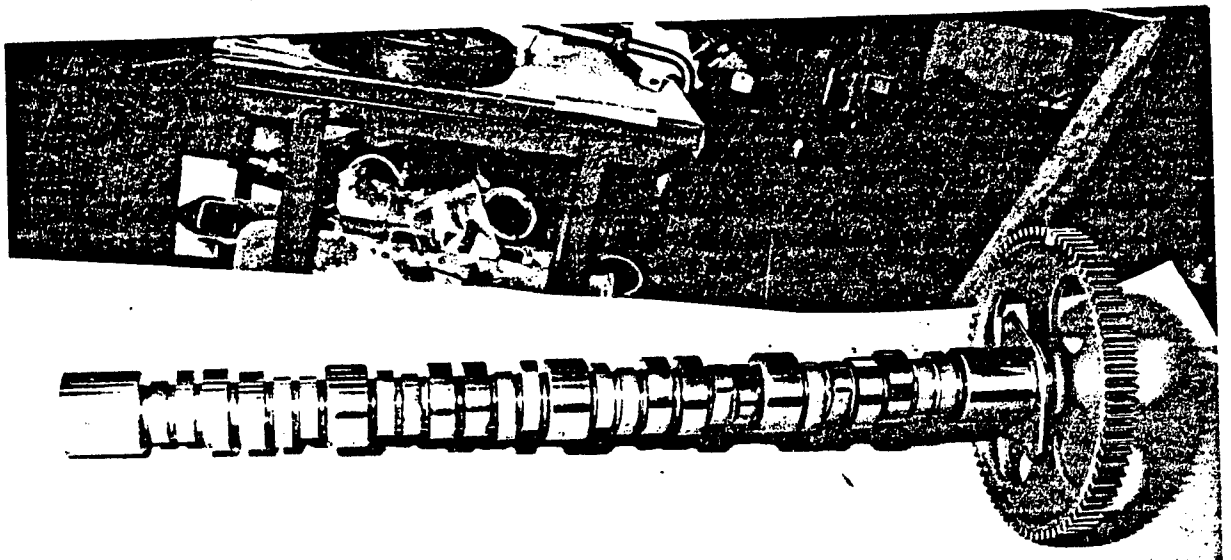
VALVE SEATS - VERY GOOD CONDITION



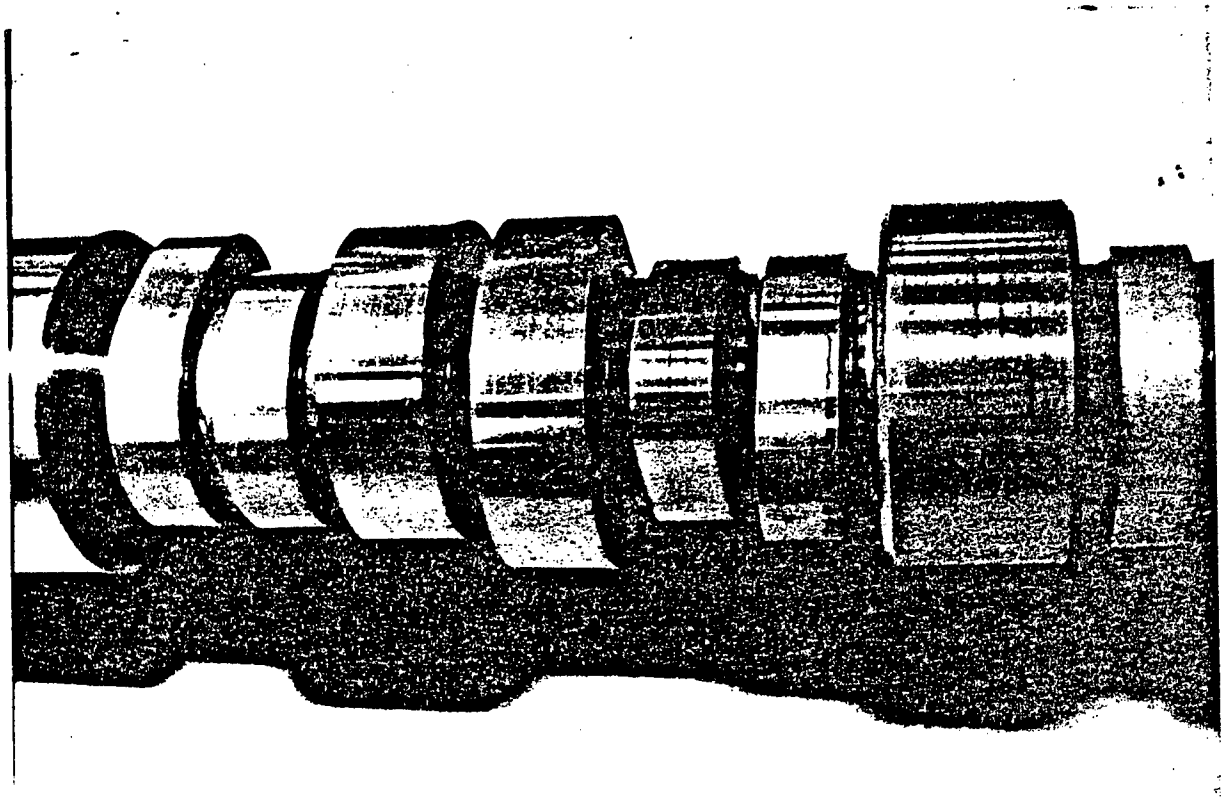
TORSIONAL VIBRATION DAMPER - ELASTOMER FATIGUE



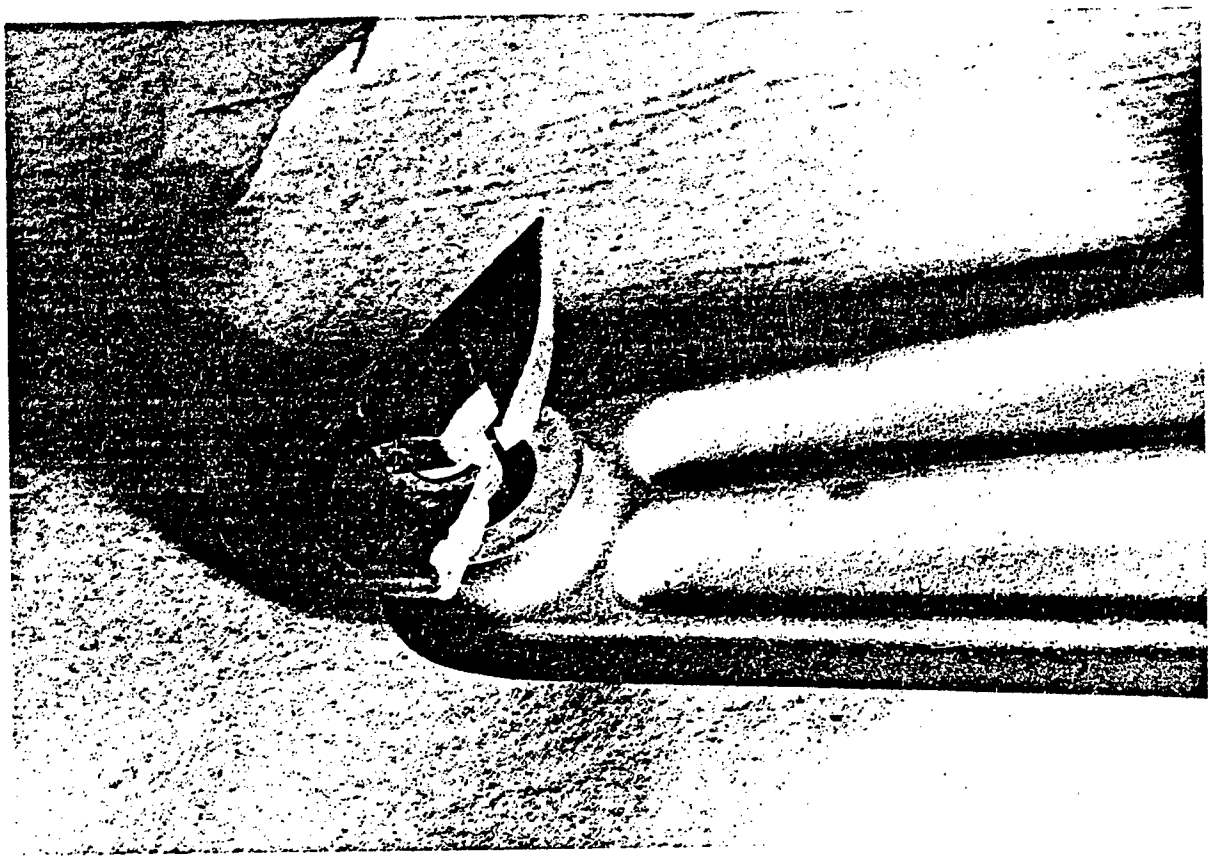
OIL PICKUP TUBE FAILURE

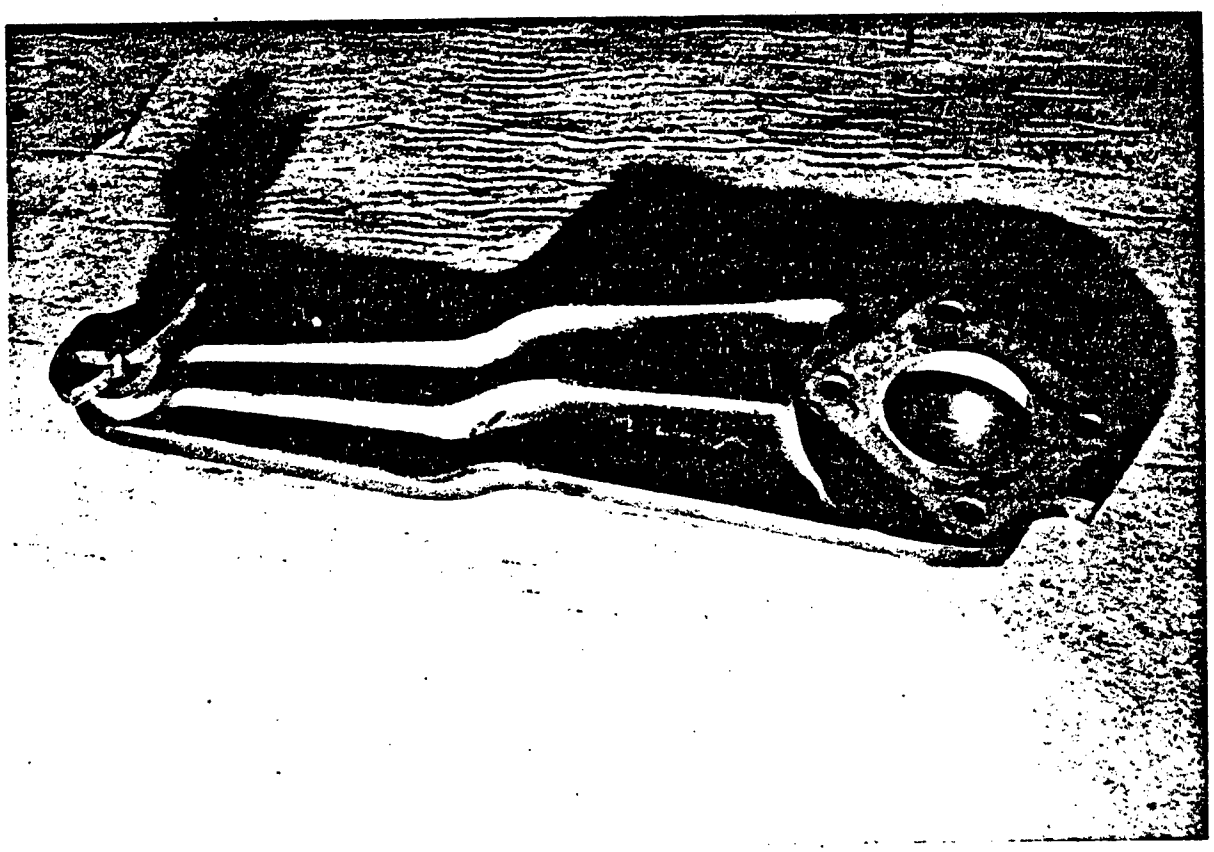


CAMSHAFT - EXCELLENT CONDITION



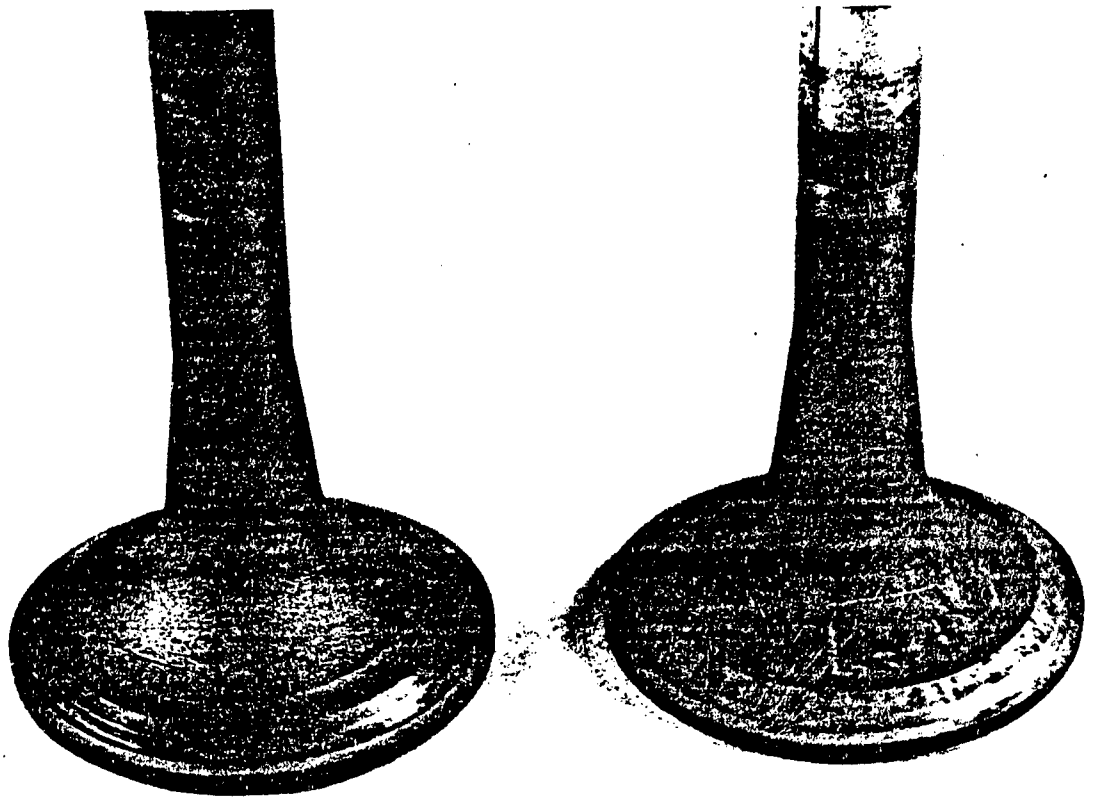
CAMSHAFT - LOBES AND BEARING SURFACES IN EXCELLENT CONDITION.



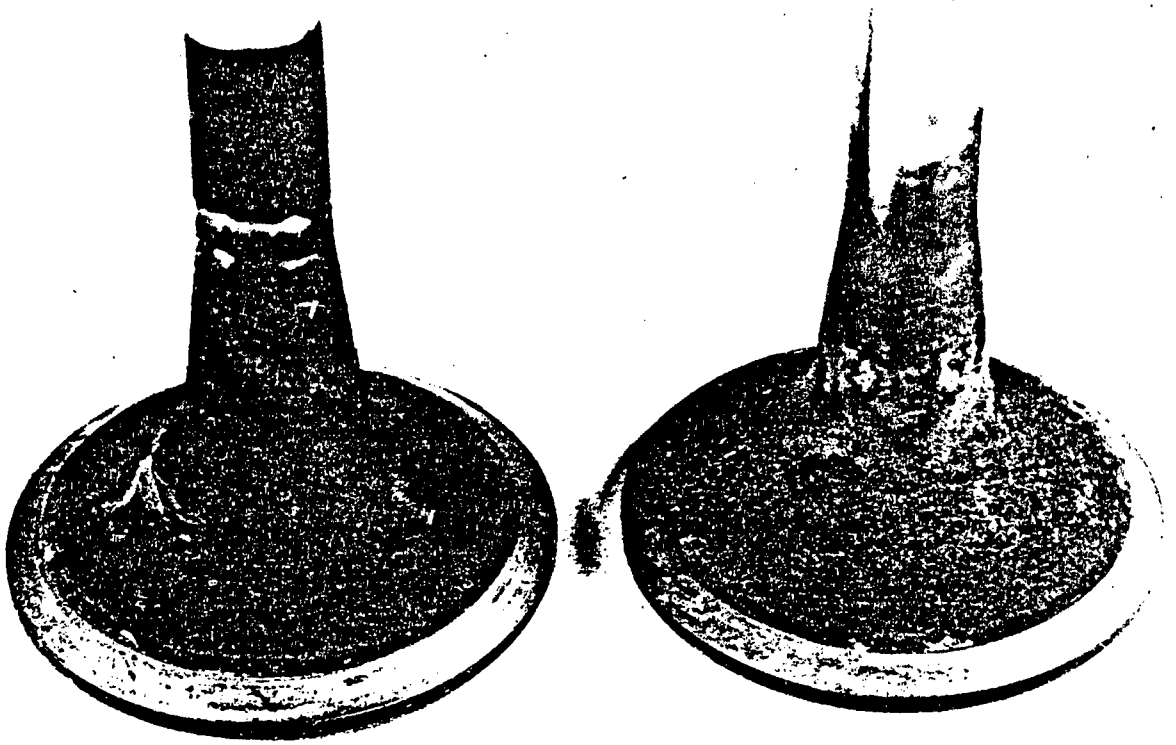


TRANSMISSION OIL COOLER SUPPORT BRACKET SHOWING BROKEN TAB FROM OIL COOLER

F-17



TYPICAL INTAKE VALVES - CLEAN - NO EVIDENCE OF STRESS

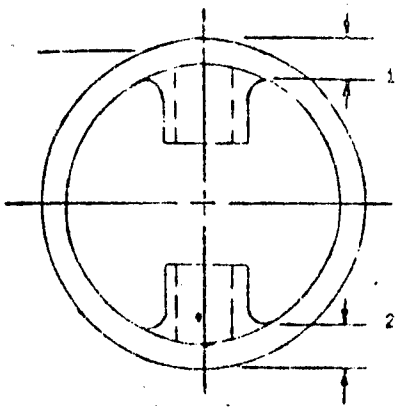


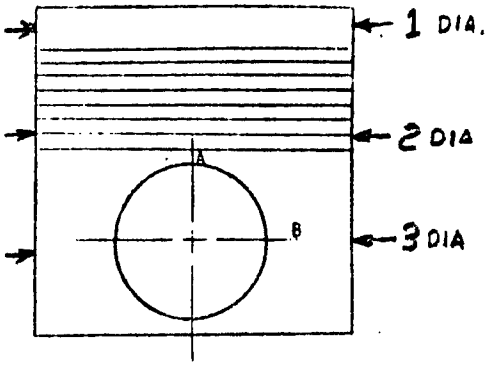
TYPICAL EXHAUST VALVES - CLEAN - NO EVIDENCE OF STRESS

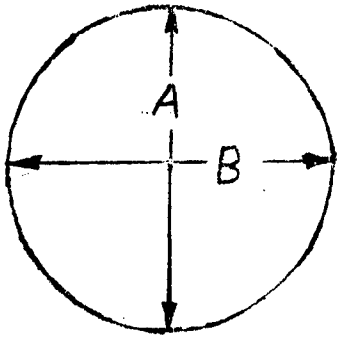
APPENDIX G

DIMENSIONAL INSPECTION SHEETS

PISTON PIN BORE & PISTON OD.	DATE 7 Sep 83	SHEET OF
	ENGINE NO. Cummins VTA-903	WORK ORDER RZ610133
	RECORDED BY DRSTA-QAA	CHECKED BY G. GREMBOS





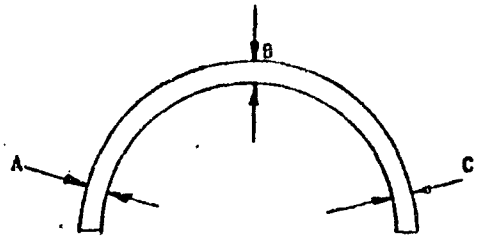


#	PISTON PIN BORE				TAPER	AVG. DIA	PISTON OD.	1 DIA		2 DIA		3 DIA	
1	A1	1.7489	A2	1.7489	0			A	5.443	A	5.468	A	5.483
	B1	1.7490	B2	1.7491	.0001			B	5.444	B	5.471	B	5.481
	OR	.0001	OR	.0002		1.7490		OR	.001	OR	.003	OR	.002
2	A1	1.7495	A2	1.7495	0			A	5.448	A	5.470	A	5.484
	B1	1.7498	B2	1.7498	0			B	5.449	B	5.470	B	5.483
	OR	.0003	OR	.0003		1.7496		OR	.001	OR	.000	OR	.001
3	A1	1.7494	A2	1.7496	.0002			A	5.449	A	5.468	A	5.485
	B1	1.7496	B2	1.7500	.0004			B	5.450	B	5.470	B	5.483
	OR	.0002	OR	.0004		1.7498		OR	.001	OR	.002	OR	.002
4	A1	1.7491	A2	1.7491	0			A	5.448	A	5.467	A	5.484
	B1	1.7492	B2	1.7492	0			B	5.450	B	5.469	B	5.483
	OR	.0001	OR	.0001		1.7492		OR	.002	OR	.002	OR	.001
5	A1	1.7491	A2	1.7491	0			A	5.448	A	5.470	A	5.483
	B1	1.7491	B2	1.7491	0			B	5.448	B	5.469	B	5.483
	OR	.0000	OR	.0000		1.7491		OR	.000	OR	.001	OR	.000
6	A1	1.7494	A2	1.7494	0			A	5.447	A	5.468	A	5.480
	B1	1.7494	B2	1.7495	.0001			B	5.453	B	5.471	B	5.484
	OR	.0000	OR	.0001		1.7494		OR	.006	OR	.003	OR	.004
7	A1	1.7492	A2	1.7492	0			A	5.448	A	5.468	A	5.484
	B1	1.7494	B2	1.7494	0			B	5.449	B	5.469	B	5.482
	OR	.0002	OR	.0002		1.7493		OR	.001	OR	.001	OR	.002
8	A1	1.7492	A2	1.7492	0			A	5.444	A	5.464	A	5.484
	B1	1.7492	B2	1.7494	.0002			B	5.444	B	5.467	B	5.483
	OR	.0000	OR	.0002		1.7493		OR	.000	OR	.003	OR	.001

NOTE: Pistons numbered 2, 3, 4, 5, 6 and 7 show visual signs of cracks in the upper half of the wrist pin bores. A liquid penetrant inspection performed gives a relative indication of the discontinuities present in the above discribed pistons.

G. V. Grembos 9/7/83

CONNECTING ROD BEARING SHELL THICKNESS	DATE 12 Sep 83	SHEET OF
	ENGINE NO. Cummins VTA-903	WORK ORDER
	RECORDED BY DRSTA-QAA	CHECKED BY D. Melanshek



CONN. ROD NO.	UPPER HALF					CONN. ROD NO.	LOWER HALF				
	LOC.	FRONT	REAR	TAPER	WEAR		LOC.	FRONT	REAR	TAPER	WEAR
1	A	.0938	.0937	.0001			A	.0935	.0937	.0002	
	B	.0935	.0931	.0004			B	.0941	.0941	.0000	
	C	.0940	.0940	.0000			C	.0932	.0935	.0003	
2	A	.0938	.0938	.0000			A	.0933	.0935	.0002	
	B	.0932	.0932	.0000			B	.0940	.0942	.0002	
	C	.0934	.0937	.0003			C	.0938	.0938	.0000	
3	A	.0935	.0935	.0000			A	.0935	.0935	.0000	
	B	.0935	.0935	.0000			B	.0940	.0940	.0000	
	C	.0935	.0935	.0000			C	.0938	.0940	.0002	
4	A	.0938	.0938	.0000			A	.0935	.0935	.0000	
	B	.0933	.0935	.0002			B	.0940	.0940	.0000	
	C	.0935	.0937	.0002			C	.0938	.0938	.0000	
5	A	.0937	.0938	.0001			A	.0938	.0935	.0003	
	B	.0932	.0935	.0003			B	.0942	.0942	.0000	
	C	.0940	.0938	.0002			C	.0935	.0935	.0000	
6	A	.0930	.0930	.0000			A	.0935	.0940	.0005	
	B	.0932	.0932	.0000			B	.0940	.0940	.0000	
	C	.0934	.0935	.0001			C	.0936	.0936	.0000	

REMARKS:

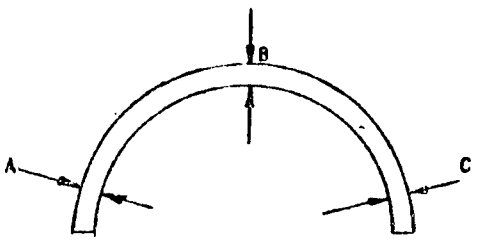
D.Zu
9-20-83

TAC FORM 22 JUL 60 4532 G

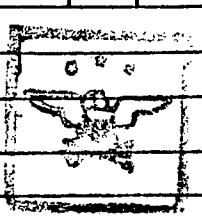
DETROIT ARSENAL
CENTER LINE, MICHIGAN

CONNECTING ROD BEARING SHELL THICKNESS

DATE	SHEET / OF
12 Sep 83	
ENGINE NO. Cummins VTA-903	WORK ORDER
RECORDED BY DRSTA-QAA	CHECKED BY D. Melanshek



CONN. ROD NO.	UPPER HALF LOC.	FRONT	REAR	TAPER	WEAR	CONN. ROD NO.	LOWER HALF LOC.	FRONT	REAR	TAPER	WEAR
7	A	.0935	.0935	.0000		7	A	.0935	.0935	.0000	
	B	.0934	.0934	.0000			B	.0942	.0942	.0000	
	C	.0940	.0940	.0000			C	.0938	.0938	.0000	
8	A	.0937	.0935	.0002		8	A	.0935	.0937	.0002	
	B	.0942	.0942	.0000			B	.0935	.0935	.0000	
	C	.0940	.0940	.0000			C	.0935	.0938	.0003	
	A						A				
	B						B				
	C						C				
	A						A				
	B						B				
	C						C				
	A						A				
	B						B				
	C						C				
	A						A				
	B						B				
	C						C				

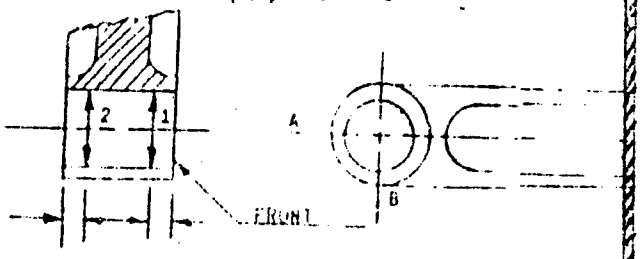


D. Mc.
9-20-83

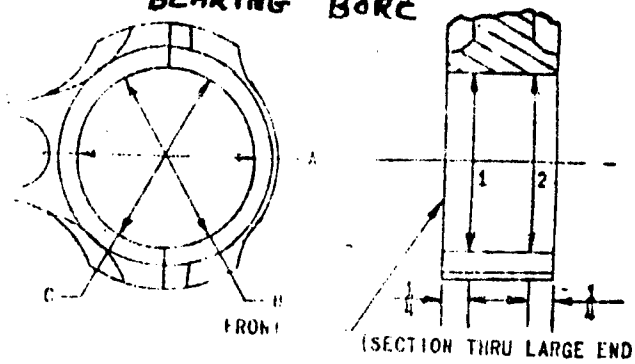
CONNECTING ROD
PIN BORE & BEARING BORE

DATE	SHEET OF
10 Sep 83	
ENGINE NO. Cummins VTA-903	WORK ORDER RZ610133
RECORDED BY DRSTA-QAA	CHECKED BY D. Melanshek

PIN BORE



BEARING BORE

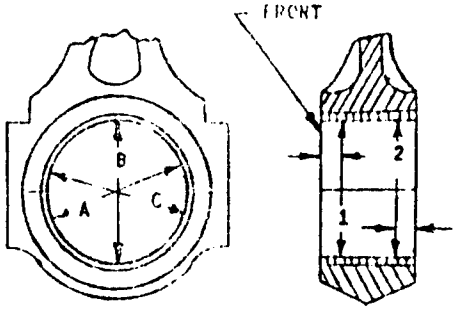


CYL.	LOC.	PIN BORE POSITION 1	2	TAPER	AVG. DIA.
1	A	1.7512	1.7512	.0000	1.7512
	B	1.7510	1.7512	.0002	1.7511
	OR	.0002	.0000	.0002	
2	A	1.7516	1.7516	.0000	1.7516
	B	1.7514	1.7516	.0002	1.7515
	OR	.0002	.0000	.0002	
3	A	1.7510	1.7510	.0000	1.7510
	B	1.7510	1.7510	.0000	1.7510
		.0000	.0000	.0000	
4	A	1.7510	1.7510	.0000	1.7510
	B	1.7510	1.7510	.0000	1.7510
	OR	.0000	.0000	.0000	
5	A	1.7510	1.7512	.0002	1.7511
		1.7510	1.7516	.0006	1.7513
		.0000	.0004	.0004	
6	A	1.7516	1.7512	.0004	1.7514
	B	1.7512	1.7512	.0000	1.7512
	OR	.0004	.0000	.0004	
7	A	1.7512	1.7510	.0002	1.7511
	B	1.7512	1.7512	.0000	1.7512
		.0000	.0002	.0002	
8	A	1.7512	1.7514	.0002	1.7513
	B	1.7512	1.7512	.0000	1.7512
		.0000	.0002	.0002	

CYL.	LOC.	BEARING BORE BORE DIA. POSITION 1	2	TAPER	AVG. DIA
1	A	3.3174	3.3174	.0000	
	B	3.3170	3.3170	.0000	
	C	3.3168	3.3172	.0004	
	OR	.0006	.0004	.0002	
	A	3.3172	3.3174	.0002	
	B	3.3174	3.3170	.0004	
	C	3.3170	3.3174	.0004	
	OR	.0004	.0004	.0000	
	A	3.3172	3.3174	.0002	
	B	3.3174	3.3176	.0002	
	C	3.3170	3.3172	.0002	
	OR	.0004	.0004	.0000	
	A	3.3172	3.3174	.0002	
	B	3.3172	3.3177	.0005	
	C	3.3172	3.3174	.0002	
		.0000	.0003	.0003	
		3.3172	3.3170	.0007	
		3.3176	3.3172	.0004	
		3.3170	3.3174	.0004	
		.0006	.0004	.0002	
	A	3.3170	3.3172	.0002	
	B	3.3169	3.3170	.0001	
	C	3.3171	3.3173	.0002	
	OR	.0002	.0003	.0001	
7	A	3.3174	3.3174	.0000	
	B	3.3170	3.3174	.0004	
	C	3.3168	3.3170	.0002	
	OR	.0006	.0004	.0002	
8	A	3.3178	3.3174	.0004	
	B	3.3170	3.3164	.0006	
	C	3.3172	3.3172	.0000	
	OR	.0008	.0010	.0002	

CONNECTING ROD BEARINGS

DATE	SHEET OF
9 Sep 83	
ENGINE NO. Cummins VTA-908	LWO NO. RZ610133
RECORDED BY DRSTA-QAA	CHECKED BY D. Melanshek



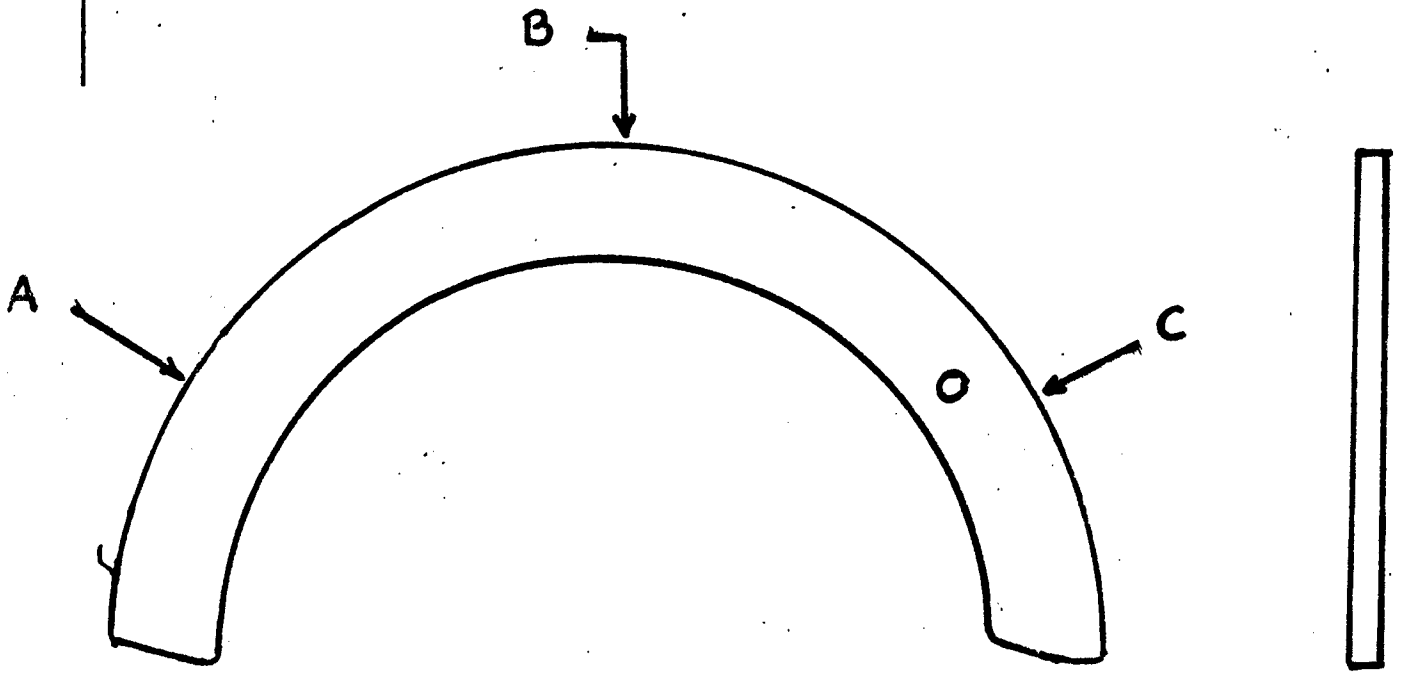
BEARING		SPEC. BEARING I.D. 1	2	TAPER	AVG. DIA.
1	A	3.1296	3.1296	.0000	3.1299
	B	3.1301	3.1306	.0005	
	C	3.1299	3.1302	.0003	
	OR	.0005	.0010	.0005	
2	A	3.1291	3.1292	.0001	3.1295
	B	3.1296	3.1300	.0004	
	C	3.1297	3.1300	.0003	
	OR	.0006	.0008	.0002	
3	A	3.1298	3.1296	.0002	3.1296
	B	3.1298	3.1298	.0000	
	C	3.1294	3.1294	.0000	
	OR	.0004	.0004	.0000	
4	A	3.1297	3.1294	.0003	3.1297
	B	3.1301	3.1299	.0002	
	C	3.1301	3.1299	.0002	
	OR	.0004	.0005	.0001	
5	A	3.1294	3.1294	.0000	3.1299
	B	3.1299	3.1304	.0005	
	C	3.1299	3.1302	.0003	
	OR	.0005	.0010	.0005	
6	A	3.1292	3.1296	.0004	3.1297
	B	3.1298	3.1302	.0004	
	C	3.1300	3.1302	.0002	
	OR	.0008	.0008	.0000	
7	A	3.1290	3.1292	.0002	3.1294
	B	3.1296	3.1298	.0002	
	C	3.1294	3.1298	.0004	
	OR	.0006	.0006	.0000	
8	A	3.1290	3.1292	.0002	3.1293
	B	3.1296	3.1298	.0002	
	C	3.1290	3.1294	.0004	
	OR	.0006	.0006	.0000	
	A				
	B				
	C				
	OR				
	A				
	B				
	C				
	OR				

BEARING		SPEC. BEARING I.D. 1	2	TAPER	AVG. DIA.
	A				
	B				
	C				
	OR				
	A				
	B				
	C				
	OR				
	A				
	B				
	C				
	OR				
	A				
	B				
	C				
	OR				
	A				
	B				
	C				
	OR				
	A				
	B				
	C				
	OR				
	A				
	B				
	C				
	OR				
	A				
	B				
	C				
	OR				

9-13-83 G-6

THRUST BEARING

DATE	SHEET OF
12 Sep 83	
ENGINE NO. Cummins VTA-903	WORK ORDER
RECORDED BY DRSTA-QAA	CHECKED BY D. Melanshek



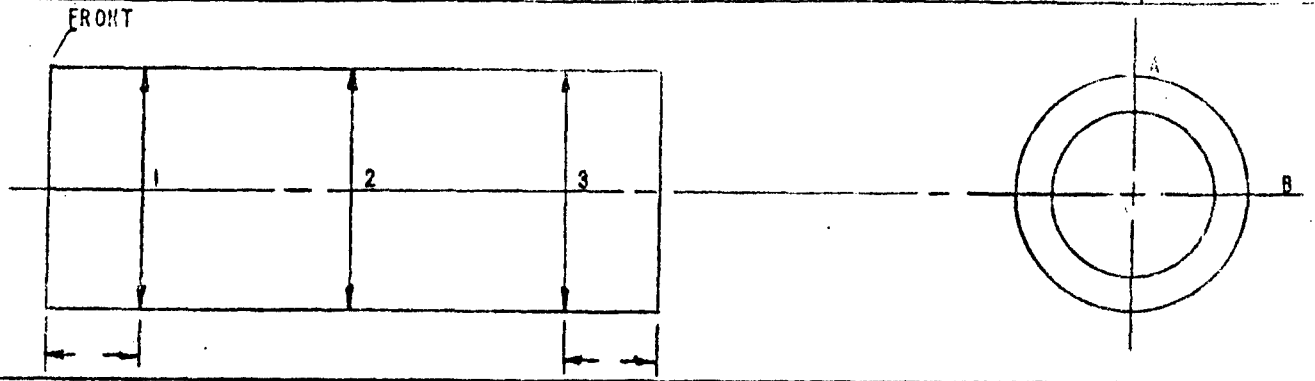
BEARG. NO.	THICK. A	THICK. B	THICK. C
UPPER REAR	.1480	.1510	.1490
LOWER REAR	.1490	.1515	.1500
UPPER FRONT	.1500	.1515	.1500
LOWER FRONT	.1495	.1513	.1498

D.M. 9-16-83

PISTON PIN DIMENSION CHECK

(LAB. SOP.)

DATE	SHEET OF
8 Sep 83	
ENGINE NO.	POPR ORDER
Cummins VTA-903	RZ610133
RECORDED BY	CHECKED BY
DRSTA-QAA	G. Grembos



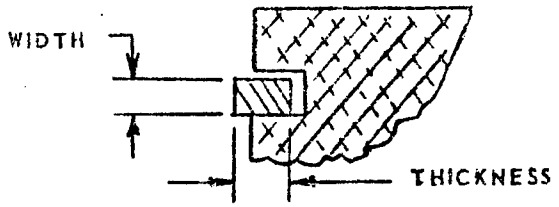
CYL. NO.	LOC.	POSITION 1	POSITION 2	POSITION 3	TAPER	AVG. WEAR
1	A1	1.7492	1.7490	1.7491	.0001	.0002
	B1	1.7491	1.7490	1.7491		.0002
	OR	.0001	.0000	.0000		
2	A2	1.7491	1.7489	1.7491		.0002
	B2	1.7491	1.7489	1.7491		.0002
	OR	.0000	.0000	.0000		
3	A3	1.7491	1.7489	1.7491		.0002
	B3	1.7491	1.7490	1.7491	.0001	.0001
	OR	.0000	.0001	.0000		
4	A1	1.7491	1.7490	1.7491		.0001
	B1	1.7491	1.7489	1.7491		.0002
	OR	.0000	.0001	.0000		
	A2					
	B2					
	OR					
	A3					
	B3					
	OR					
	A1					
	B1					
	OR					
	A2					
	B2					
	OR					
	A3					
	B3					
	OR					

CYL. NO.	LOC	POSITION 1	POSITION 2	POSITION 3	TAPER	AVG. WEAR
5	A1	1.7491	1.7489	1.7491		.0002
	B1	1.7491	1.7489	1.7491		.0002
	OR	.0000	.0000	.0000		
6	A2	1.7492	1.7490	1.7492		.0002
	B2	1.7492	1.7490	1.7492		.0002
	OR	.0000	.0000	.0000		
7	A3	1.7492	1.7490	1.7492		.0002
	B3	1.7492	1.7490	1.7492		.0002
	OR	.0000	.0000	.0000		
8	A1	1.7495	1.7493	1.7495		.0002
	B1	1.7495	1.7493	1.7495		.0002
	OR	.0000	.0000	.0000		
	A2					
	B2					
	OR					
	A3					
	B3					
	OR					
	A1					
	B1					
	OR					
	A2					
	B2					
	OR					
	A3					
	B3					
	OR					

G. G. Grembos 8/9/83

PISTON RING THICKNESS AND WIDTH
(LAB. SOP.)

DATE	SHEET OF
12 Sep 83	
ENGINE NO. Cummins VTA-903	WORK ORDER RZ610133
RECORDED BY DRSTA-QAA	CHECKED BY G. Grembos



CYL. NO.		THICKNESS RING NO. TOP	2	3	4	5	OIL 6	WIDTH RING NO. TOP	2	3	4	5	OIL 6
1	MAX.	.1130		.1460		.1860		.207		.205		.159	
	MIN.	.1125		.1455		.1855		.204		.204		.157	
2	MAX.	.1145		.1455		.1860		.205		.206		.160	
	MIN.	.1140		.1450		.1850		.202		.203		.157	
3	MAX.	.1150		.1465		.1860		.206		.206		.159	
	MIN.	.1140		.1460		.1855		.203		.204		.156	
4	MAX.	.1150		.1450		.1860		.207		.209		.160	
	MIN.	.1145		.1445		.1855		.204		.204		.155	
5	MAX.	.1150		.1460		.1860		.205		.211		.162	
	MIN.	.1140		.1450		.1860		.203		.208		.157	
6	MAX.	.1165		.1465		.1860		.208		.205		.159	
	MIN.	.1160		.1455		.1855		.205		.203		.156	
7	MAX.	.1150		.1455		.1860		.206		.210		.158	
	MIN.	.1140		.1450		.1855		.203		.215		.155	
8	MAX.	.1135		.1460		.1860		.207		.206		.158	
	MIN.	.1130		.1455		.1855		.205		.202		.156	
	MAX.												
	MIN.												
	MAX.												
	MIN.												
	MAX.												
	MIN.												
	MAX.												
	MIN.												

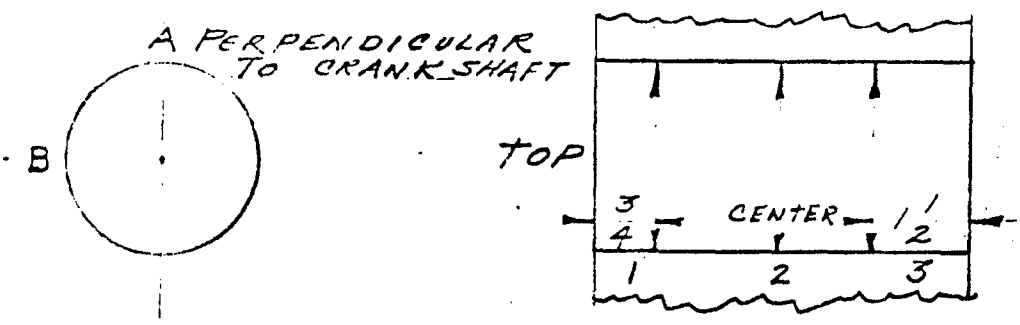
TAC FORM 4534 F
22 JUL 60

G. Grembos 09/12/83

CYLINDER LINER BORES

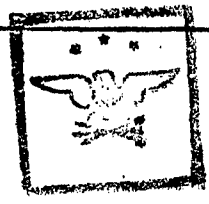
RIGHT BANK

DATE	SHEET OF
13 Sep 83	—
ENGINE NO	SERIAL NO.
Cummins VTA-903	RZ610133
RECORDED BY	CHECKED BY
DRSTA-QAA	G. Grembos



CYL NO.	LOC.	POSITION 1	2	3	TAPER	REMARKS
1	A	5.4995	5.4998	5.4992	.0006	AVERAGE DIA = 5.4999
	B	5.5000	5.5008	5.5004	.0008	
	OR	.0005	.0010	.0012		
2	A	5.4993	5.4998	5.4993	.0005	AVERAGE DIA = 5.4999
	B	5.5005	5.5008	5.5000	.0008	
	OR	.0012	.0010	.0007		
3	A	5.4991	5.5002	5.4996	.0011	AVERAGE DIA = 5.5001
	B	5.5008	5.5012	5.4999	.0013	
	OR	.0017	.0010	.0003		
4	A	5.4999	5.5004	5.4994	.0010	AVERAGE DIA = 5.5001
	B	5.5004	5.5011	5.4999	.0012	
	OR	.0005	.0007	.0005		
	A					
	B					
	OR					
	A					
	B					
	OR					

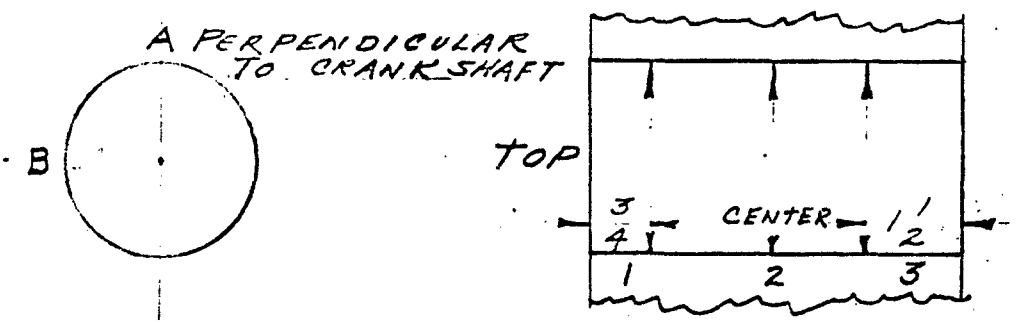
G. Grembos 09/13/83



CYLINDER LINER BORES

LEFT BANK

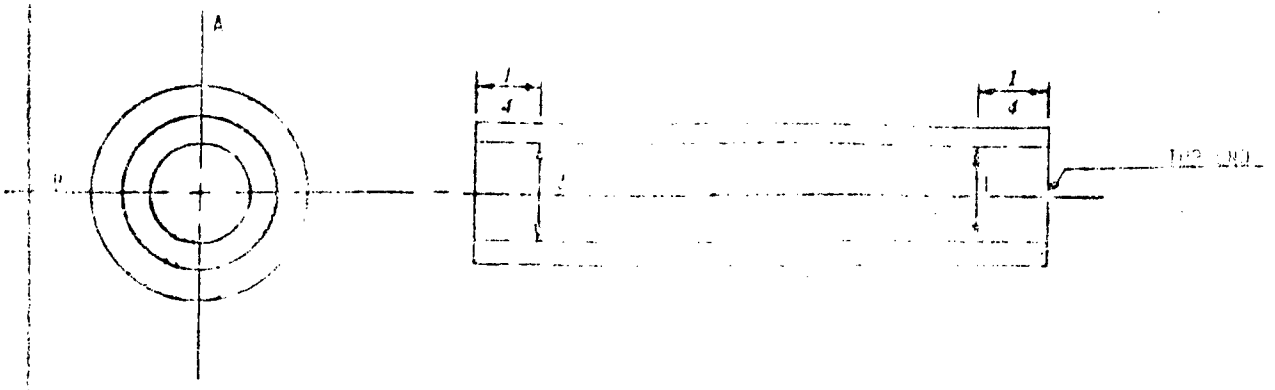
DATE	SHEET OF
13 Sep 83	
ENGINE NO	SERIAL NO.
Cummins VTA-903	RZ610133
RECORDED BY	CHECKED BY
DRSTA-QAA	G. Grembos



CYL NO.	LOC.	POSITION 1	2	3	TAPER	REMARKS
5	A	5.4992	5.5004	5.4994	.0012	
	B	5.4999	5.5012	5.5001	.0013	AVERAGE DIA = 5.5000
	OR	.0007	.0008	.0007		
6	A	5.4996	5.4998	5.4990	.0008	
	B	5.5002	5.5008	5.4996	.0012	AVERAGE DIA = 5.4998
	OR	.0006	.0010	.0006		
7	A	5.4998	5.5005	5.5000	.0007	
	B	5.5002	5.5013	5.4996	.0017	AVERAGE DIA = 5.5002
	OR	.0004	.0008	.0004		
8	A	5.4998	5.5008	5.4998	.0010	
	B	5.5002	5.5009	5.4998	.0011	AVERAGE DIA = 5.5002
	OR	.0004	.0001	.0000		
	A					
	B					
	OR					
	A					
	B					
	OR					

G. M. Grembos 09/13/83

XXXXXX VALVE GUIDE BORE DIMENSIONS (LAB. SOP.)	DATE 10 Sep 83	SHEET OF
	ENGINE NO. Cummins VTA-903	WORK ORDER RZ610133
	RECORDED BY DRSTA-QAA	CHECKED BY G. GREMBOS

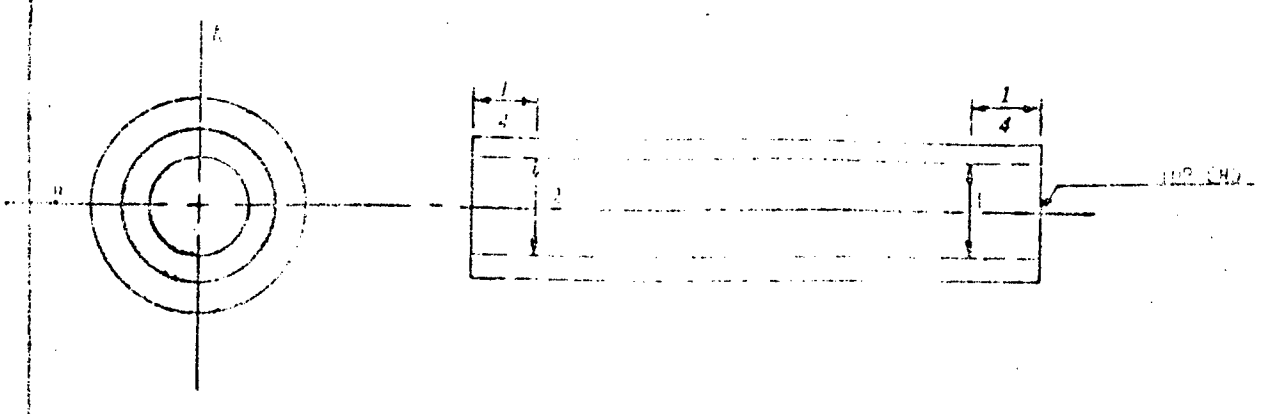


CYL. NO.	LOC.	POSITION TOP 1	POSITION BOTTOM 2	TAPER	CYL. NO.	LOC.	POSITION TOP 1	POSITION BOTTOM 2	TAPER
1a Int	A	.4533	.4533	.0000	1b Exh	A	.4532	.4520	.0012
	B	.4533	.4535	.0002		B	.4531	.4520	.0011
	A	.0000	.0002			OR	.0001	.0000	
1c Int	A	.4537	.4537	.0000	1d Exh	A	.4535	.4535	.0000
	B	.4528	.4525	.0003		B	.4528	.4528	.0000
	OR	.0009	.0012			OR	.0007	.0007	
2a Int	A	.4536	.4537	.0001	2b Exh	A	.4535	.4534	.0001
	B	.4538	.4535	.0003		B	.4525	.4525	.0000
	OR	.0002	.0002			OR	.001	.0009	
2c Int	A	.4538	.4530	.0008	2d Exh	A	.4536	.4530	.0004
	B	.4538	.4528	.001		B	.4535	.4530	.0005
	OR	.0000	.0002			OR	.0001	.0000	
	A					A			
	B					B			
	OR					OR			
	A					A			
	B					B			
	OR					OR			

G.F.D. 10/9/83

TAC FORM 4533 C 22 JUL

~~XXXXX~~ VALVE GUIDE BORE DIMENSIONS (LAP. SOP.)	DATE 10 Sep 83	SHEET _ OF	
	ENGINE NO. Cummins VTA-903	WORK ORDER RZ610133	
	RECEIVED BY DRSTA-QAA	CHECKED BY G. Grembos	



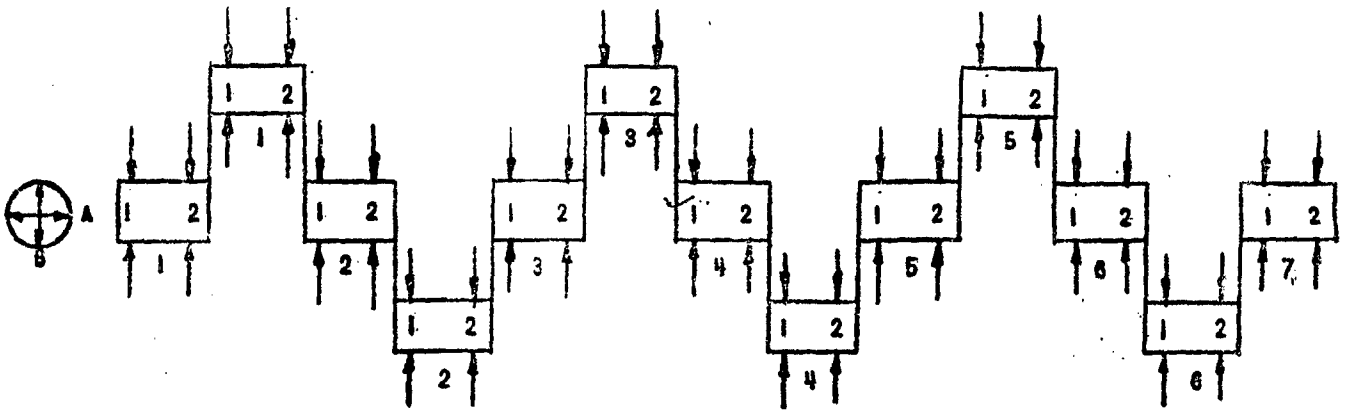
CYL. NO.	LOC.	POSITION TOP 1	POSITION BOTTOM 2	TAPER
3a Int	A	.4534	.4525	.0009
	B	.4534	.4525	.0009
	A	.0000	.0000	
3c Int	A	.4538	.4529	.0009
	B	.4541	.4527	.0014
	OR	.0003	.0002	
4a Int	A	.4533	.4525	.0008
	B	.4533	.4525	.0008
	OR	.0000	.0000	
4c Int	A	.4537	.4525	.0012
	B	.4537	.4525	.0012
	OR	.0000	.0000	
	A			
	B			
	OR			
	A			
	B			
	OR			

CYL. NO.	LOC.	POSITION TOP 1	POSITION BOTTOM 2	TAPER
3b Exh	A	.4535	.4520	.0015
	B	.4536	.4523	.0013
	OR	.0001	.0003	
3d Exh	A	.4538	.4523	.0015
	B	.4537	.4525	.0012
	OR	.0001	.0002	
4b Exh	A	.4533	.4528	.0005
	B	.4535	.4530	.0005
	OR	.0002	.0002	
4d Exh	A	.4535	.4530	.0005
	B	.4535	.4535	.0000
	OR	.0000	.0005	
	A			
	B			
	OR			
	A			
	B			
	OR			

E.K. Fenton 10/9/83

CRANKSHAFT JOURNAL AND CRANKPIN DIAMETERS (LAB. SOP.)

DATE	SHEET OF
ENGINE NO. Cummins VTA-903	WORK ORDER RZ610133
RECORDED BY DRSTA-QAA	CHECKED BY G. Furton

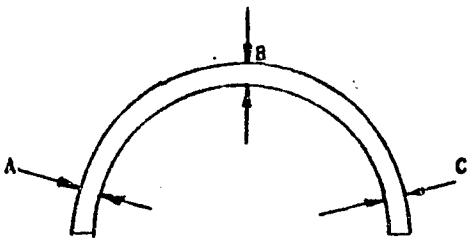


NOTE: *Crankpin #1 is in vertical position.*

JOURNAL		MAIN JOURNAL DIAMETERS				CRANKPIN		CRANKPIN DIAMETERS			
NO.	LOC.	1	2	TAPER	WEAR	NO.	LOC.	1	2	TAPER	WEAR
1	A	3.7495	3.7497	.0002		4	A	3.1248	3.1248	.0000	
	B	3.7498	3.7496	.0002			B	3.1247	3.1247	.0000	
	O-R	.0003	.0001				O-R	.0001	.0001		
1	A	3.1242	3.1234	.0002		5	A	3.7496	3.7494	.0002	
	B	3.1241	3.1243	.0002			B	3.7493	3.7493	.0000	
	O-R	.0001	.0001				O-R	.0003	.0001		
2	A	3.7498	3.7495	.0003			A				
	B	3.7497	3.7496	.0001			B				
	O-R	.0001	.0001				O-R				
2	A	3.1248	3.125	.0003			A				
	B	3.1247	3.1249	.0002			B				
	O-R	.0001	.0001				O-R				
3	A	3.7498	3.7496	.0002			A				
	B	3.7495	3.7496	.0001			B				
	O-R	.0003	.0000				O-R				
3	A	3.1248	3.1246	.0002			A				
	B	3.1248	3.1245	.0003			B				
	O-R	.0000	.0001				O-R				
4	A	3.7497	3.7497	.0000			A				
	B	3.7495	3.7496	.0001			B				
	O-R	.0002	.0001				O-R				

CONNECTING ROD BEARING SHELL THICKNESS

DATE	SHEET OF
6 Sep 83	
ENGINE NO. Cummins VTA-903	WORK ORDER RZ610133
RECORDED BY DRSTA-QAA	CHECKED BY D. Melanshek

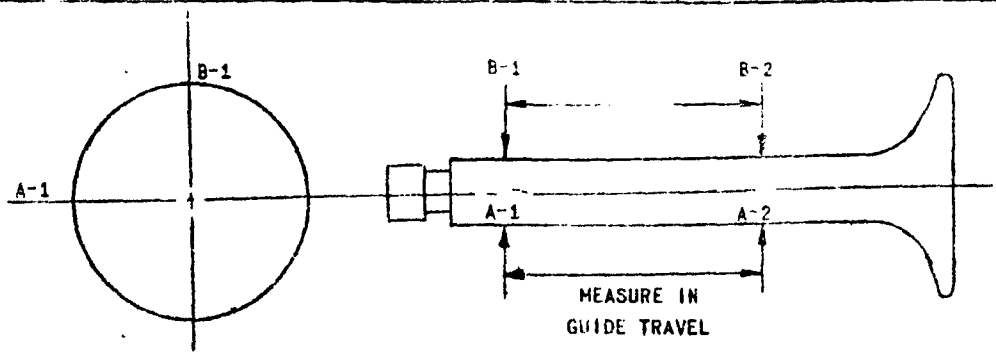


CONN. ROD NO.	UPPER HALF LOC.	FRONT	REAR	TAPER	WEAR	CONN. ROD NO.	LOWER HALF LOC.	FRONT	REAR	TAPER	WEAR
1	A	.1540	.1540	.0000		1	A	.1538	.1538	.0000	
	B	.1545	.1544	.0001			B	.1543	.1543	.0000	
	C	.1530	.1535	.0005			C	.1536	.1536	.0000	
2	A	.1535	.1535	.0000		2	A	.1532	.1535	.0003	
	B	.1545	.1543	.0002			B	.1542	.1542	.0000	
	C	.1531	.1535	.0004			C	.1536	.1536	.0000	
3	A	.1537	.1535	.0002		3	A	.1535	.1535	.0000	
	B	.1542	.1540	.0002			B	.1540	.1540	.0000	
	C	.1533	.1533	.0000			C	.1536	.1535	.0001	
4	A	.1532	.1532	.0000		4	A	.1535	.1535	.0000	
	B	.1543	.1541	.0002			B	.1538	.1540	.0002	
	C	.1538	.1538	.0000			C	.1533	.1535	.0002	
5	A	.1535	.1535	.0000		5	A	.1534	.1534	.0000	
	B	.1543	.1544	.0001			B	.1542	.1542	.0000	
	C	.1535	.1535	.0000			C	.1536	.1536	.0000	
	A						A				
	B						B				
	C						C				

NOTES:

D. M
9.20.83

EXHAUST AND INTAKE VALVE STEM DIMENSIONS (LAB SOF)	DATE 8 Sep 83	SHEET OF
	ENGINE NO. Cummins VTA-903	WORK ORDER RZ610133
	RECORDED BY DRSTA-QAA	CHECKED BY D. Melanshek



CYL. NO.	LOC.	POSITION 1	POSITION 2	TAPER
EXH. # 1	A	.4500	.4500	.0000
	B	.4500	.4500	.0000
	OR	.0000	.0000	.0000
INT. # 1	A	.4505	.4502	.0003
	B	.4503	.4503	.0000
	OR	.0002	.0001	.0001
EXH. # 2	A	.4507	.4503	.0004
	B	.4507	.4504	.0003
	OR	.0000	.0001	.0001
INT. # 2	A	.4504	.4498	.0006
	B	.4503	.4498	.0005
	OR	.0001	.0000	.0001
EXH. # 3	A	.4502	.4502	.0000
	B	.4502	.4502	.0000
	OR	.0000	.0000	.0000
INT. # 3	A	.4502	.4500	.0002
	B	.4502	.4498	.0004
	OR	.0000	.0002	.0002
EXH. # 4	A	.4505	.4505	.0000
	B	.4505	.4505	.0000
	OR	.0000	.0000	.0000
INT. # 4	A	.4505	.4498	.0007
	B	.4505	.4498	.0007
	OR	.0000	.0000	.0007
EXH. #	A			
	B			
	OR			
INT. #	A			
	B			
	OR			
EXH. #	A			
	B			
	OR			
INT. #	A			
	B			
	OR			

CYL. NO.	LOC.	POSITION 1	POSITION 2	TAPER
EXH. # 1	A	.4503	.4503	.0000
	B	.4503	.4503	.0000
	OR	.0000	.0000	.0000
INT. # 1	A	.4505	.4502	.0003
	B	.4505	.4502	.0003
	OR	.0000	.0000	.0000
EXH. # 2	A	.4500	.4502	.0002
	B	.4500	.4501	.0001
	OR	.0000	.0001	.0001
INT. # 2	A	.4506	.4501	.0005
	B	.4505	.4501	.0004
	OR	.0001	.0000	.0001
EXH. # 3	A	.4499	.4499	.0000
	B	.4499	.4499	.0000
	OR	.0000	.0000	.0000
INT. # 3	A	.4505	.4505	.0000
	B	.4505	.4505	.0000
	OR	.0000	.0000	.0000
EXH. # 4	A	.4502	.4502	.0000
	B	.4503	.4501	.0002
	OR	.0001	.0001	.0001
INT. # 4	A	.4504	.4502	.0002
	B	.4504	.4502	.0002
	OR	.0000	.0000	.0002
EXH. #	A			
	B			
	OR			
INT. #	A			
	B			
	OR			
EXH. #	A			
	B			
	OR			
INT. #	A			
	B			
	OR			

9-20-83

APPENDIX H

NATO REQUIRED DATA SHEETS

FULL LOADS AT 100 HOUR INTERVALS

PART LOADS AT ENDURANCE COMPLETION

ENGINE Type:	N°:	Place date:
FULL CHARGE PERFORMANCES INITIAL ☐ FINAL ☐		Reference:
FUEL:	OIL type:	BRAKE type:
Volume mass: kg/dm³	grade:	Full Load at 0 Test Hours

AMBI-ENT	t0	°C	34.5	30.1	30.2	30.01	29.9	29.7	29.6	
	p0	mbar	998.9	998.9	998.9	998.9	998.9	998.9	998.9	
PERFORMANCES	n	rpm	2600	2400	2200	2000	1800	1600	1400	
	M	m.daN	1387	1439	1420	1386	1334	1258	1151	
	p	kw	378	362	327	290	252	211	169	
	pme	bar	11.8	12.2	12.1	11.8	11.3	10.7	9.8	
FUEL	Cs/bsfc	g/kw h	231	223	217	218	223	228	246	
	Qc	mm^3/cycle	156.6	165.7	158.6	156.3	153.5	148.8	146.1	
	qm	kg/h	82.6	80.6	70.8	63.4	56	48.3	43.5	
OIL	tH	°C	119	118.2	116.7	115.7	114.5	113.4	112.5	
	pH	bar	3.91	3.68	3.39	3.07	2.73	2.42	2.07	
WATER	te	°C	90.7	90.9	90.98	92.1	91.2	90.89	90.7	
	ts	°C	94.2	94.4	94.3	94.33	94.4	94.55	94.5	
INLET	t1	°C	29.39	30.16	30.23	30.01	29.95	29.7	29.59	
	p0 - p1	mbar	11.35	9.96	7.77	5.45	3.64	2.46	1.44	
	t2	°C	153.33	144.4	129.87	113.88	97.6	82.58		
	p2	bar	1.224	1.173	1.083	.833	.634	.457	.298	
	t2'	°C	102.3	100.477	97.4	94.8	92.44	90.7	89.55	
	p2-p2'	mbar	---	---	---	---	---	---	---	
EXHAUST	t3	°C	672.9	651.1	637	645.7	662	706.9	738.7	
	p3	bar	1.185	1.032	.829	.626	.440	.308	.198	
	t4	°C	554.4	537	537	557	595.4	634.8	670	
	p4-p0	mbar	38.17	28.8	17.35	7.47	2.96	.32	1.42	
	Smoke	bosch	---	---	---	---	---	---	---	
BLOW-BY		dm^3/mn								

ENGINE Type:	N°:	Place date:
FULL CHARGE PERFORMANCES INITIAL ☐ FINAL ☐		Reference:

FUEL:	OIL type:	BRAKE type:
Volume mass: kg/dm³	grade:	Full Load At 100 Test Hrs

AMBI-ENT	t0	°C	30.8	31.1	29.7	31.1	30.5	30.8	31.1	
	p0	mbar	987.6	987.6	987.6	987.6	987.6	987.6	987.6	
PERFORMANCES	n	r.p.m	2600	2400	2200	2000	1800	1600	1400	
	M	m.daN	1411	1442.8	1425.2	1398	1352	1267	1162	
	P	kw	384.4	362.6	328.3	292.8	254.8	211.9	170.3	
	pme	bar	11.9	12.2	12.1	11.9	11.5	10.7	9.86	
FUEL	Cs/bsfc	g/kw h	216	223.2	217.8	216.6	221.4	230.5	247.6	
	Qc	mm^3/cycle	157	166.2	176	156.1	154.7	150.7	148.7	
	qm	kg/h	82.8	80.9	71.2	63.31	56.5	48.9	42.2	
OIL	tH	°C	117.8	117.2	115.7	115	113.9	112.7	111.2	
	pH	bar	4.72	4.42	4.1	3.64	3.14	2.67	2.2	
WATER	te	°C	90.6	89.5	89.76	90.7	90.5	90.2	90.1	
	ts	°C	94.5	93.7	93.6	94.3	94.27	94.14	94.3	
INLET	t1	°C	22.4	23.4	23.9	24.9	24.9	26.2	26.3	
	p0 - p1	mbar	13.3	11.9	9.5	7.2	5.33	3.9	4.18	
	t2	°C	149.3	138.9	123.5	105.4	93.1	78.5	65.3	
	p2	bar	1.27	1.213	1.10	.869	.663	.465	.301	
	t2'	°C	103.9	100.8	96.9	93.9	90.5	88.3	87.06	
	p2-p1'	mbar	---	---	---	---	---	---	---	
EXHAUST	t3	°C	667.1	637.1	622.4	633.3	661.7	696	729	
	p3	bar	1.23	1.083	.868	.659	.469	.313	.199	
	t4	°C	496.2	486.7	452	466.2	574	615.5	658.6	
	p4 - p0	mbar	36.9	25.12	15.3	6.00	1.27	.72	1.997	
	Smoke	Bosch	---	---	---	---	---	---	---	
BLOW - BY		dm^3/mn								

ENGINE Type:	N°:	Place date:
FULL CHARGE PERFORMANCES INITIAL ☐ FINAL ☐		Reference:
FUEL:	OIL type:	BRAKE type:
Volume mass: kg/dm³	grade:	Full Load At 200 Test Hours

AMBIENT	t0	°C	33.0	33.2	32.5	34	32.3	30.7	29.5	
	p0	mbar	1006	1006	1006	1006	1006	1006	1006	
PERFORMANCE	n	r.p.m	2600	2400	2200	2000	1800	1600	1400	
	M	mdaN	1385.8	1441.4	1432	1402	1348	1273	1167.5	
	P	kw	377.2	360.5	330	294	254	213.3	171.1	
	pme	bar	11.76	12.2	12.15	11.9	11.4	10.8	9.91	
FUEL	Cs/bsfc	g/kwh	230.5	223.8	217.8	214.7	219.6	227.5	237	
	Qc	mm^3/cycle	165.1	165.9	161	155.4	152.8	149.5	125.5	
	qm	kg/h	87.03	80.7	71.8	63	55.7	48.5	40.7	
OIL	tH	°C	118.2	117.8	116.5	115.2	114.1	112.8	111.2	
	pH	bar	4.75	4.42	4.08	3.64	3.15	2.67	2.19	
WATER	te	°C	90.1	90.8	90.6	90.5	90.4	90.2	90.04	
	ts	°C	93.7	94.4	94.2	94.1	94.1	94.1	94.2	
INLET	t1	°C	20.9	21.9	23.2	23.8	23.5	24.6	24,25	
	p0 - p1	mbar	13.9	12.5	10.1	7.64	5.7	4.2	3.18	
	t2	°C	144.3	136.3	122.7	107.3	90.9	76.5	63.11	
	p2	bar	1.25	1.21	1.061	.865	.660	.466	.302	
	t2'	°C	103.1	101.2	97.6	93.8	90.8	88.32	86.8	
	p2-p1	mbar	---	---	---	---	---	---	---	
EXHAUST	t3	°C	49.9	48.1	46.7	47.5	50.1	53.4	56.3	
	p3	bar	1.04	1.05	.846	.643	.457	.321	.186	
	t4	°C	542	533	530.4	549.9	582	621.3	654.5	
	p4-p0	mbar	47.2	36.02	20.2	8.34	2.91	.5	.55	
	Smoke	Bosch	---	---	---	---	---	---	---	
BLOW-BY		cm^3/mn								

ENGINE Type:	N°:	Place date:
FULL CHARGE PERFORMANCES INITIAL ☐ FINAL ☐		Reference:
FUEL:	OIL type:	BRAKE type:
Volume mass: kg/dm³	grade:	Full Load At 300 Hours

AMBIENT	t0	°C	29.9	29.4	28.5	24.6	23.5	23.5	23.5	
	p0	mbar	996.1	996.1	996.1	996.1	996.1	996.1	996.1	
PERFORMANCE	n	r.p.m	2600	2400	2203	2000	1801	1601	1400	
	M	m.daN	1383.1	1430.6	1410.2	1373.6	1327.5	1244.8	1139.0	
	P	kw	376.6	359.6	324.8	287.6	250.2	208.6	167.0	
	pme	bar	11.7	12.1	12.0	11.6	11.3	10.6	9.7	
FUEL	Cs/bsfc	g/kw.h	233.0	225.7	219.0	220.2	226.9	234.8	250.6	
	Qc	mm^3/cycle	199.6	200.0	191.2	187.6	186.6	181.1	177.1	
	qm	kg/h	87.7	81.1	71.2	63.4	56.8	49.0	41.9	
OIL	tH	°C	125.1	124.0	121.8	120.0	118.7	117.6	116.0	
	pH	bar	4.8	4.5	4.3	3.9	3.4	3.0	2.5	
WATER	te	°C	89.3	88.8	89.0	89.1	89.1	88.9	88.7	
	ts	°C	93.1	92.7	92.6	92.5	92.6	92.7	92.6	
INLET	t1	°C	27.1	26.6	25.8	22.0	21.1	21.1	21.2	
	p0 - p1	mbar	15.1	13.6	11.1	8.5	5.9	4.7	3.6	
	t2	°C	152.3	142.5	126.2	106.2	89.8	74.1	60.8	
	p2	bar	1.22	1.19	1.05	.873	.676	.474	.310	
	t2'	°C	103.7	101.1	97.0	92.5	89.2	86.9	85.3	
	p2-p2'	mbar	---	---	---	---	---	---	---	
EXHAUST	t3	°C	671.3	647.3	631.4	633.6	661.3	693.8	725.2	
	p3	bar	1.18	1.07	.859	.649	.464	.311	.199	
	t4	°C	554.2	539.4	534.9	547.4	580.7	619.0	654.5	
	p4-p0	mbar	45.6	36.7	21.8	9.76	4.16	1.64	.299	
	Smoke	Bosch	---	---	---	---	---	---	---	
BLOW-BY		dm^3/mn	---	---	---	---	---	---	---	

ENGINE Type:	N°:	Place date:
FULL CHARGE PERFORMANCES INITIAL ☐ FINAL ☐		Reference:
FUEL:	OIL type:	BRAKE type:
Volume mass: kg/dm³	grade:	Full Load At 400 Test Hours

AMBI-ENT	t0	°C	26.0	26.4	26.9	27.3	27.6	27.7	28.3	
	p0	mbar	1002.8	1002.8	1002.8	1002.8	1002.8	1002.8	1002.8	
PERFORMANCE	n	r.p.m	1405	1600	1799	1996	2202	2303		
	M	m.daN	1156.7	1248.9	1342.4	1375.0	1411.6	1417		
	P	kW	169.6	209.2	253.0	287.9	325.2	341.2		
	pme	bar	9.8	10.6	11.4	11.7	12.0	12.0		
FUEL	Cs/bsfc	g/kW h	240.3	237.8	226.3	221.4	222.0	224.5		
	Qc	mm^3/cycle	171.4	184.2	188.1	188.8	194.0	197.1		
	qm	kg/h	40.7	49.8	57.2	63.7	72.2	76.7		
OIL	tH	°C	114.4	118.1	119.9	121.2	122.9	123.9		
	pH	bar	2.6	3.0	3.4	3.9	4.3	4.4		
WATER	te	°C	88.8	90.6	90.8	90.6	90.7	90.6		
	ts	°C	92.7	94.2	94.2	94.1	94.1	94.1		
INLET	t1	°C	24.9	25.1	25.2	25.3	25.3	25.7		
	p0 - p1	mbar	3.35	4.31	5.82	7.91	10.51	11.82		
	t2	°C	65.31	78.8	94.7	110.3	125.9	135.0		
	p2	bar	.317	.474	.672	.865	1.06	1.14		
	t2'	°C	85.21	88.71	91.23	94.24	98.21	100.21		
	p2-p2'	mbar	---	---	---	---	---	---	---	
EXHAUST	t3	°C	729.4	701.4	665.8	639.9	632.2	637.0		
	p3	bar	.196	.305	.445	.446	.857	.962		
	t4	°C	656.8	626.0	587.7	553.1	534.3	534.0		
	p4-p0	mbar	.075	1.96	4.90	10.36	22.43	29.27		
	Smoke	Bosch	---	---	---	---	---	---	---	
BLOW-BY		cm^3/mn	---	---	---	---	---	---		

ENGINE

PERFORMANCES

				Part Load At 1400 RPM						
				85%	70%	60%	50%	40%	25%	
AMBIENT	t0	°C		25.32	25.58	25.72	25.93	26.04	26.52	
	p0	mbar		1001.2	1001.2	1001.2	1001.2	1001.2	1001.2	
PERFORMANCE	n	rpm		1400	1400	1400	1400	1400	1400	
	M	mdaN		984.5	809.5	694.3	579.0	473.2	297.0	
	p	kw		144.3	118.6	101.8	84.9	69.4	43.5	
	pme	bar		8.4	6.9	5.9	4.9	4.0	2.5	
FUEL	Ks/bsfc	g/kw h		235.4	227.5	236.0	236.0	244.5	276.4	
	Qc	mm^3/cycle		77.1	61.4	55.0	45.0	38.7	27.5	
	qm	kg/h		33.9	27.0	24.1	20.0	17.0	12.1	
OIL	tH	°C		111.3	106.3	107.2	106.1	104.6	103.2	
	pH	bar		2.6	2.8	2.7	2.8	2.8	2.8	
WATER	te	°C		87.7	86.6	90.6	90.5	91.7	92.8	
	ts	°C		90.7	88.9	92.6	92.2	93.0	93.9	
INLET	t1	°C		23.9	24.3	24.6	24.8	25.1	25.6	
	p0 - p1	mbar		3.2	3.0	3.0	2.9	2.9	2.8	
	t 2	°C		54.4	47.8	45.4	42.8	40.6	37.7	
	p 2	bar		.46	.33	.27	.22	.17	.11	
	t2'	°C		83.5	82.1	85.4	85.6	85.9	87.3	
	p2-p2'	mbar		---	---	---	---	---	---	
EXHAUST	t3	°C		629.0	539.3	499.7	447.9	401.5	328.7	
	p3	bar		.154	.132	.120	.107	.094	.077	
	t 4	°C		576.9	501.8	466.8	419.4	374.5	305.1	
	p4-p0	mbar		3.46	2.21	1.74	1.02	.049	1.19	
	Smoke	Bosch	---	---	---	---	---	---	---	
BLOW-BY		dm^3/mn	---	---	---	---	---	---	---	

ENGINE

PERFORMANCES

				Part Load At 1600 RPM						
				85%	70%	60%	50%	40%	25%	
AMBI-ENT	t0	°C		25.7	25.0	26.4	26.4	26.7	26.7	
	p0	mbar		998.2	998.2	998.2	998.2	998.2	998.2	
PERFORMANCES	n	rpm		1600	1600	1600	1600	1600	1600	
	M	mdaN		1063.0	871.9	744.4	625.1	508.5	309.2	
	p	kw		178.1	146.1	124.8	104.7	85.2	51.8	
	pme	bar		9.0	7.4	6.3	5.3	4.3	2.6	
FUEL	Ks/bsfc	g/kw.h		233.6	231.8	234.2	241.5	247.0	276.8	
	Qc	mm^3/cycle		153.8	125.4	108.0	93.6	77.7	52.9	
	qm	kg/h		41.6	33.9	29.2	25.3	21.0	14.3	
OIL	tH	°C		114.5	112.1	110.7	109.5	107.8	105.6	
	pH	bar		3.1	3.1	3.2	3.3	3.3	3.4	
WATER	te	°C		91.4	91.4	92.1	92.7	93.0	93.9	
	ts	°C		94.3	93.7	93.9	94.2	94.3	94.4	
INLET	t1	°C		24.1	24.5	25.0	25.2	25.4	25.7	
	p0 - p1	mbar		4.0	3.7	3.5	3.5	3.3	3.2	
	t2	°C		66.6	58.1	54.1	50.4	46.8	41.8	
	p2	bar		.73	.54	.42	.37	.30	.18	
	t2'	°C		87.9	87.3	87.6	87.9	88.1	88.1	
	p2 - p2'	mbar		---	---	---	---	---	---	
EXHAUST	t3	°C		631.8	564.9	522.6	478.0	431.2	347.8	
	p3	bar		.250	.211	.190	.170	.150	.121	
	t4	°C		568.8	516.6	480.8	442.8	400.8	323.1	
	p4 - p0	mbar		.074	.025	.448	1.19	1.54	2.61	
	Smoke	Bosch		---	---	---	---	---	---	
BLOW - BY		dm^3/mn		---	---	---	---	---	---	

ENGINE

PERFORMANCES

				Part Load At 1800 RPM						
				- 85%	70%	60%	50%	40%	25%	
AMBI-ENT	t0	°C		27.8	28.0	28.3	28.7	28.6	28.8	
	p0	mbar		998.2	998.2	998.2	998.2	998.2	998.2	
PERFORMANCE	n	rpm		1800	1800	1800	1800	1800	1800	
	M	mdaN		1141.7	932.9	790.5	672.6	534.3	340.4	
	p	kw		215.2	175.8	149.0	126.8	100.7	64.1	
	pme	bar		9.7	7.9	6.7	5.7	4.5	2.9	
FUEL	Cs/bsfc	g/kwh		225.7	226.9	237.8	237.2	245.8	281.0	
	Qc	mm^3/cycle		159.4	131.1	116.3	98.6	81.2	59.2	
	qm	kg/h		48.5	39.9	35.4	30.0	24.7	18.0	
OIL	tH	°C		116.8	114.7	113.1	111.4	109.6	107.5	
	pH	bar		3.5	3.5	3.6	3.7	3.7	3.8	
WATER	te	°C		90.6	91.6	92.2	92.6	92.7	93.4	
	ts	°C		93.4	94.1	94.1	94.3	93.9	94.3	
INLET	t1	°C		26.0	26.2	26.8	27.3	27.3	27.8	
	p0 - p1	mbar		5.3	4.7	4.6	4.3	4.0	3.9	
	t2	°C		83.1	72.2	67.1	61.5	55.6	49.2	
	p2	bar		1.1	.81	.69	.56	.43	.28	
	t2'	°C		89.6	89.6	89.4	89.2	88.8	89.0	
	p2-p2'	mbar		---	---	---	---	---	---	
EXHAUST	t3	°C		620.8	569.4	536.0	493.2	442.9	370.3	
	p3	bar		.382	.318	.283	.250	.214	.171	
	t4	°C		549.7	510.4	484.2	449.4	407.6	341.9	
	p4-p0	mbar		3.5	2.2	1.7	1.0	.49	1.19	
	Smoke	Bosch		---	---	---	---	---	---	
BLOW-BY		cm^3/mn		---	---	---	---	---	---	

ENGINE

PERFORMANCES

				Part Load At 2000 RPM						
				85%	70%	60%	50%	40%	25%	
AMBIENT	t0	°C		29.5	29.3	29.1	29.1	29.2	29.3	
	p0	mbar		998.2	998.2	998.2	998.2	998.2	998.2	
PERFORMANCE	n	rpm		2000	2000	2000	2000	2000	2000	
	M	mdaN		1174.3	953.3	827.2	679.4	549.2	343.1	
	P	kw		245.9	199.6	173.2	142.3	115.0	71.8	
	pme	bar		10.0	8.1	7.0	5.8	4.7	2.9	
FUEL	Cs/bsfc	g/kw h		220.8	226.3	232.9	243.9	250.6	285.2	
	Qc	mm^3/cycle		160.7	133.7	119.5	102.6	85.2	60.7	
	qm	kg/h		54.3	45.2	40.4	34.7	28.8	20.5	
OIL	tH	°C		119.1	116.3	117.4	113.0	111.6	109.0	
	pH	bar		3.8	4.0	4.0	4.1	4.1	4.3	
WATER	te	°C		92.0	92.0	92.2	92.5	92.8	93.2	
	ts	°C		94.9	94.3	94.1	94.2	94.0	94.1	
INLET	t1	°C		27.7	27.5	27.4	27.5	27.9	28.1	
	p0 - p1	mbar		6.9	6.1	5.8	5.4	5.0	4.5	
	t 2	°C		98.3	85.4	79.2	71.7	64.7	54.9	
	p 2	bar		1.4	1.1	.95	.78	.60	.39	
	t2'	°C		93.3	91.7	91.2	90.6	90.0	89.4	
	p2-p2'	mbar		---	---	---	---	---	---	
EXHAUST	t3	°C		600.7	559.1	531.3	496.0	452.5	379.8	
	p3	bar		.532	.440	.397	.345	.291	.221	
	t 4	°C		523.9	492.1	471.9	444.9	409.7	346.2	
	p4-p0	mbar		6.6	5.0	4.3	3.6	3.1	1.1	
	Smoke	bosch		---	---	---	---	---	---	
BLOW - BY		dm^3/mn		---	---	---	---	---	---	

ENGINE

PERFORMANCES

				Part Load At 2200 RPM						
				- 85%	- 70%	60%	50%	40%	25%	
AMBI-ENT	t0	°C		27.5	27.7	27.9	28.0	28.8	28.2	
	p0	mbar		995.5	995.5	995.5	995.5	995.5	995.5	
PERFORMANCE	n	rpm		2200	2200	2200	2200	2200	2200	
	M	mdaN		1200	983.1	847.5	705.1	565.4	347.1	
	P	kw		276.4	226.5	195.2	162.4	130.3	79.9	
	pme	bar		10.2	8.3	7.2	6.0	4.8	2.9	
FUEL	Cs/bsfc	g/kwh		223.8	226.9	232.3	242.7	253.6	295.6	
	Qc	mm^3/cycle		166.2	138.2	122.1	106.2	89.0	63.5	
	qm	kg/h		61.8	51.4	45.4	39.5	33.1	23.6	
OIL	tH	°C		119.1	116.8	115.5	114.4	112.7	110.4	
	pH	bar		4.4	4.4	4.5	4.5	.46	4.7	
WATER	te	°C		90.5	91.0	91.6	92.5	92.6	92.9	
	ts	°C		93.4	93.2	93.6	94.2	94.0	93.8	
INLET	t1	°C		25.8	26.2	26.4	26.7	27.0	27.3	
	p0 - p1	mbar		8.1	7.5	6.9	5.6	5.5	5.1	
	t2	°C		97.6	89.4	81.8	73.4	60.9	54.3	
	p2	bar		1.4	1.2	1.0	.81	.54	.38	
	t2'	°C		93.5	92.9	92.7	91.8	90.7	90.3	
	p2-p2'	mbar		---	---	---	---	---	---	
EXHAUST	t3	°C		552.2	526.6	497.7	460.3	393.6	340.6	
	p3	bar		.594	.516	.453	.379	.287	.237	
	t4	°C		477.2	457.7	436.1	407.6	351.1	304.2	
	p4-p0	mbar		9.3	6.7	5.3	4.4	2.7	1.3	
	Smoke	bosch		---	---	---	---	---	---	
BLOW - BY		dm^3/mn		---	---	---	---	---	---	

ENGINE

PERFORMANCES

				Part Load At 2300 RPM						
				85%	70%	60%	50%	40%	25%	
AMBIENT	t0	°C		29.5	29.8	30.0	30.3	30.4	30,4	
	p0	mbar		995.5	995.5	995.5	995.5	995.5	995.5	
PERFORMANCES	n	rpm		2300	2300	2300	2300	2300	2300	
	M	mdaN		1209.6	993.9	848.4	709.2	573.6	355.3	
	P	kw		291.3	239.4	204.4	170.8	138.1	85.5	
	pme	bar		10.3	8.4	7.2	6.0	4.9	3.0	
FUEL	Cs/bsfc	g/kwh		222.6	245.7	234.8	245.7	258.5	295.6	
	Qc	mm^3/cycle		167.0	140.7	123.2	107.8	91.8	65.1	
	qm	kg/h		64.9	54.7	47.9	41.9	35.7	25.3	
OIL	tH	°C		121.8	119.0	116.9	115.4	113.8	111.6	
	pH	bar		4.4	4.5	4.5	4.6	4.6	4.8	
WATER	te	°C		91.8	91.8	92.0	92.3	92.5	92.9	
	ts	°C		94.7	94.1	94.1	94.1	94.0	03.8	
INLET	t1	°C		27.4	27.8	28.1	28.6	28.9	29.2	
	p0 - p1	mbar		10.4	9.2	8.4	7.7	7.0	6.1	
	t 2	°C		120.2	106.3	97.1	89.1	81.0	67.2	
	p 2	bar		1.9	1.6	1.3	1.1	.93	.60	
	t2'	°C		98.6	95.8	94.4	93.6	92.9	91.8	
	p2-p2'	mbar		---	---	---	---	---	---	
EXHAUST	t3	°C		596.6	556.7	527.2	500.9	468.9	399.4	
	p3	bar		.794	.667	.578	.504	.435	.326	
	t 4	°C		504.5	474.8	453.7	454.4	410.3	354.2	
	p4-p0	mbar		20.0	11.8	8.4	5.5	5.3	3.2	
	Smoke	bosch		---	---	---	---	---	---	
BLOW-BY		dm^3/mn		---	---	---	---	---	---	

ENGINE

PERFORMANCES

				Part Load At 2400 RPM						
				85%	70%	60%	50%	40%	25%	
AMBI-ENT	t0	°C		31.5	31.6	31.7	31.8	31.9	31.8	
	p0	mbar		995.5	995.5	995.5	995.5	995.5	995.5	
PERFORMANCE	n	rpm		2400	2400	2400	2400	2400	2400	
	M	mdaN		1213.6	980.4	854.3	709.2	558.7	345.8	
	p	kw		305.0	246.4	214.5	178.2	140.4	86.9	
	pme	bar		10.3	8.3	7.3	6.0	4.7	2.9	
FUEL	Ks/bsfc	g/kwh		226.3	232.3	237.2	247.5	263.4	303.5	
	Qc	$\frac{mm^3}{cycle}$		170.1	141.3	125.7	108.7	91.2	65.1	
	qm	kg/h		69.0	57.3	51.0	44.1	37.0	26.4	
OIL	tH	°C		122.6	119.4	117.9	116.1	114.7	112.1	
	pH	bar		4.5	4.6	4.6	4.7	4.8	4.9	
WATER	te	°C		91.6	91.6	91.9	92.1	92.5	92.7	
	ts	°C		94.7	93.8	94.0	93.8	93.8	93.7	
INLET	t1	°C		29.2	29.7	29.8	30.0	30.5	30.6	
	p0 - p1	mbar		11.6	10.0	9.2	8.3	7.6	7.4	
	t2	°C		130.7	113.6	104.7	95.5	85.8	71.1	
	p2	bar		2.1	1.7	1.4	1.2	.99	.66	
	t2'	°C		100.3	97.2	95.8	94.7	93.9	92.5	
	p2-p2'	mbar		---	---	---	---	---	---	
EXHAUST	t3	°C		606.4	558.5	532.6	503.1	467.6	404.4	
	p3	bar		.890	.726	.644	.557	.472	.362	
	t4	°C		508.4	473.3	454.7	433.6	407.9	356.0	
	p4-p0	mbar		27.3	15.2	10.6	7.1	5.5	4.0	
	Smoke	Bosch		---	---	---	---	---	---	
BLOW-BY		dm^3/mn		---	---	---	---	---	---	

ENGINE

PERFORMANCES

				Part Load At 2600 RPM						
				85%	70%	60%	50%	40%	25%	
AMBI-ENT	t0	°C		33.1	33.1	33.1	33.0	32.5	32.7	
	p0	mbar		995.5	995.5	995.5	995.5	995.5	995.5	
PERFORMANCES	n	rpm		2600	2600	2600	2600	2600	2600	
	M	mdaN		1179.7	960.0	827.2	687.5	551.9	343.1	
	p	kw		321.2	261.4	225.2	187.2	150.3	93.4	
	pme	bar		10.0	8.2	7.0	5.8	4.7	2.9	
FUEL	Cs/bstc	g/kwh		233.5	234.8	243.3	253.0	272.8	321.1	
	Gc	mm^3/cycle		170.9	139.5	124.9	107.9	93.3	68.3	
	qm	kg/h		75.1	61.3	54.9	47.4	41.0	30.0	
OIL	tH	°C		124.0	120.9	119.3	117.8	116.5	114.25	
	pH	bar		4.7	4.8	4.8	4.9	4.9	5.1	
WATER	te	°C		91.3	91.5	91.6	92.0	92.4	92.6	
	ts	°C		94.4	93.9	93.8	93.7	93.8	93.7	
INLET	t1	°C		30.7	30.7	31.1	31.3	30.7	31.5	
	p0 - p1	mbar		13.2	11.7	10.7	9.8	9.0	7.5	
	t2	°C		141.8	124.3	115.8	105.4	95.6	80.6	
	p2	bar		2.2	1.9	1.6	1.4	1.2	.81	
	t2'	°C		102.8	99.7	98.1	96.4	95.4	93.5	
	p2-p2'	mbar		---	---	---	---	----	----	
EXHAUST	t3	°C		623.2	566.7	537.8	506.6	476.4	418.8	
	p3	bar		1.02	.857	.755	.663	.582	.447	
	t4	°C		516.7	474.8	453.1	430.6	407.9	362.2	
	p4-p0	mbar		37.3	25.4	17.3	11.4	8.5	5.7	
	Smoke	Bosch		---	---	---	---	---	---	
BLOW-BY		dm^3/mn		---	---	---	---	---	---	

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